

# RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

Vol. 64

APRIL, 1955

No. 4

## CONTENTS

INTRODUCTION OF CARMAN LECTURER.	<i>W. Edward Chamberlain, M.D.</i>	481
ROENTGEN EXAMINATION OF THE ACUTE ABDOMEN. THE CARMAN LECTURE.	<i>Barton R. Young, M.D.</i>	483
CINEFLUOROGRAPHIC ANALYSIS OF THE MECHANISM OF SWALLOWING.	<i>G. H. Ramsey, M.D., J. S. Watson, M.D., R. Gramiak, M.D., and S. A. Weinberg, M.D.</i>	498
ROENTGEN CHARACTERISTICS OF OSTEOGENIC SARCOMA OF THE JAW.	<i>Robert S. Sherman, M.D., and Myron Melamed, M.D.</i>	519
PATENT DUCTUS ARTERIOSUS. A CRITICAL EVALUATION OF ITS ROENTGEN SIGNS.	<i>Theodore E. Keats, M.D., and Howard L. Steinbach, M.D.</i>	528
SYNDROME ASSOCIATED WITH MUCOCELE OF THE SPHENOID SINUS. REPORT OF TWO CASES AND THEIR RADIOGRAPHIC FINDINGS.	<i>Howard M. Simon, Jr., M.D., and Fred R. Tingwald, M.D.</i>	538
A METHOD OF DOSIMETRY FOR CARCINOMA OF THE CERVIX UTILIZING A MODIFIED MANCHESTER TECHNIC WITH COBALT 60.	<i>I. Meschan, M.D., T. H. Oddie, D.Sc., F. Inst. P., and George Regnier, M.D.</i>	546
THE PHYSICAL ASPECTS OF THE UTILIZATION OF THE TRIPARTITE RIGID COBALT 60 APPLICATOR FOR TREATMENT OF CARCINOMA OF THE CERVIX.	<i>T. H. Oddie, D.Sc., F. Inst. P., and I. Meschan, M.D.</i>	560
THE USE OF RADIOIODINE IN THE STUDY OF THYROID DISORDERS.	<i>J. P. Nicholson, B.A., B.Sc., C. W. Wilson, M.Sc., Ph.D., F. Inst. P., K. A. Newton, M.R.C.P., D.M.R.T., and R. G. C. MacLaren, F.R.C.S., D.M.R.T.</i>	567
THE EFFECT OF KILOVOLTAGE AND GRID RATIO ON SUBJECT CONTRAST IN RADIOGRAPHY.	<i>H. E. Seemann, Ph.D., and H. R. Splettstoesser, B.S.</i>	572
INTRAGASTRIC GALLSTONE.	<i>J. K. Afflerbaugh, M.D., and Harold A. Cole, M.D.</i>	581
VOLVULUS OF THE BLIND ILEAL LOOP FOLLOWING ILEOSIGMOIDOSTOMY. A CASE WITH PERFORATION.	<i>Joan Eliasoph, M.D., Richard H. Marshak, M.D., and Bernard S. Wolf, M.D.</i>	584
WORK IN PROGRESS: SOME PHYSICAL CHARACTERISTICS OF A 45-MEV LINEAR ELECTRON ACCELERATOR FOR THERAPEUTIC APPLICATIONS.	<i>Erich M. Uhlmann, M.D., F.A.C.R., and Charles L. Hsieh, Ph.D.</i>	587
EDITORIAL: DENTAL RADIOGRAPHY.	<i>Harry M. Worth, F.R.C.P. (C), L.D.S.</i>	588
ANNOUNCEMENTS AND BOOK REVIEWS.		590
IN MEMORIAM.		594
RADIOLOGICAL SOCIETIES: SECRETARIES AND MEETING DATES.		600
ABSTRACTS OF CURRENT LITERATURE.		604

# RADIOLOGY

A MONTHLY PUBLICATION DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

PUBLISHED BY THE RADILOGICAL SOCIETY OF NORTH AMERICA

## EDITOR

HOWARD P. DOUB, M.D.

Henry Ford Hospital, Detroit 2, Mich.

## ASSOCIATE EDITORS

Hugh F. Hare, M.D.

Leo G. Rigler, M.D.

Laurence L. Robbins, M.D.

## PUBLICATION COMMITTEE

Robert P. Barden, M.D., Chairman

James W. J. Carpenter, M.D.

George L. Sackett, M.D.

## EDITORIAL ASSISTANTS

Marion B. Crowell, A.B.

Florence Roper Jeffery, A.B.

## ADVISORY EDITORIAL BOARD

Richard H. Chamberlain, M.D.

Harold Cummins, Ph.D.

Edith H. Quimby, Sc.D.

Arthur Purdy Stout, M.D.

## GENERAL INFORMATION

RADIOLOGY is entered as second class matter at Syracuse, New York, and Easton, Penna., under the Act of August 24, 1912, and accepted November 24, 1934. RADIOLOGY is published by the Radiological Society of North America as its official Journal. Subscription rate \$10.00 per annum. Canadian postage, \$1.00 additional. Foreign postage, \$2.00 additional. Single copies \$2.00 each. All correspondence relative to business matters connected with the Radiological Society of North America and RADIOLOGY, or remittance for non-member subscriptions, should be made payable to the Radiological Society of North America and should be addressed to the BUSINESS MANAGER, DONALD S. CHILDS, M.D., 713 E. GENESEE STREET, SYRACUSE 2, NEW YORK. In requesting change of address, both the old and the new address should be given.

Dues to the Radiological Society of North America include subscription to RADIOLOGY and should be paid to DONALD S. CHILDS, M.D., SECRETARY-TREASURER, 713 E. GENESEE STREET, SYRACUSE 2, N. Y.

The rate for "want" advertisements for insertion in the Classified Section is 8 cents per word, minimum charge \$2.00. Remittance should accompany order. Rates for display advertisements will be furnished upon request.

Inquiries regarding the program for the Annual Meeting of the Society for the current year should be sent to the President.

changes as may be necessary to make the contributions conform to the editorial standards of RADIOLOGY. Correspondence relating to publication of papers should be addressed to the Editor, HOWARD P. DOUB, M.D., HENRY FORD HOSPITAL, DETROIT 2, MICHIGAN.

Original articles will be accepted only with the understanding that they are contributed solely to RADIOLOGY. Articles in foreign languages will be translated if they are acceptable. Manuscripts should be typewritten double-spaced, with wide margins, on good paper, and the original, not a carbon copy, should be submitted. The author's full address should appear on the manuscript. It is advisable that a copy be retained for reference as manuscripts will not be returned.

Illustrations and tables should be kept within reasonable bounds, as the number which can be published without cost to the author is strictly limited. For excess figures and for illustrations in color, estimates will be furnished by the Editor. Photographic prints should be clear and distinct and on glossy paper. Drawings and charts should be in India ink on white or on blue-lined coordinate paper. Blueprints will not reproduce satisfactorily. All photographs and drawings should be numbered, the top should be indicated, and each should be accompanied by a legend with a corresponding number. Authors are requested to indicate on prints made from photomicrographs the different types of cells to which attention is directed, by drawing lines in India ink and writing in the margin. The lines will be reproduced, and the words will be set in type. Attention should be called to points which should be brought out in completed illustrations, by tracings and suitable texts. These instructions should be concise and clear.

As a convenience to contributors to RADIOLOGY who are unable to supply prints for their manuscripts, the Editor can arrange for intermediate prints from roentgenograms.

Contents of RADIOLOGY copyrighted 1955 by The Radiological Society of North America, Inc.

# RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES  
PUBLISHED BY THE RADIOLOGICAL SOCIETY OF NORTH AMERICA

Vol. 64

APRIL 1955

No. 4

## Introduction of the Carman Lecturer

W. EDWARD CHAMBERLAIN, M.D.

M<sup>R</sup>. PRESIDENT, Members of the Society and Guests, Ladies and Gentlemen: The privilege of introducing our 1954 Carman Lecturer is gratefully acknowledged and sincerely appreciated.

Barton Rogers Young was born in Spring City, Penna., in 1903. His pre-medical and medical school studies were carried out at Temple University, where he received his M.D. degree in 1929. When I moved from San Francisco to Philadelphia in 1930, Bart was a handsome young lieutenant in the United States Navy and had just completed his internship at the Philadelphia Naval Hospital. He resigned his commission to begin a residency in the new department of radiology which we had barely begun to build.

Dr. Young's career has been a distinguished one, indeed, and few men have contributed so much to the scientific and organizational aspects of medicine and radiology. Author of some forty scientific journal publications, he was chosen by the Year Book Publishers in 1947 to write the widely used text book, *The Skull, Sinuses and Mastoids*, published in 1948. To each of the eight annual volumes (1946 to 1953 inclusive) entitled *Progress in Neurology and Psychiatry*, (New York, Grune and Stratton), Dr. Young contributed a valuable chapter on "Radiology of the Skull and Central Nervous System." To the *Nelson Loose-Leaf Roentgenology*, edited by Dr. Ross Golden (1948), he contributed a chapter on "Radiology

of the Soft Tissues of the Air and Food Passages of the Neck."

Dr. Young has frequently been elected to important offices in medical and radiological organizations. To mention but a few, he was elected President of his Medical Alumni Association in 1941; a member of the Council, College of Physicians of Philadelphia, in 1953; Secretary of the Philadelphia Roentgen Ray Society in 1936 and its President in 1945. Continuously to the present moment he has been a member of the Board of Chancellors of the American College of Radiology since 1952, and Secretary of the American Roentgen Ray Society since 1949.

Dr. Young's academic career is noteworthy. At the conclusion of his residency in 1933 he became Instructor in Radiology at Temple University, School of Medicine. His colleagues on the Faculty repeatedly voted for his advancement, and in 1945 he became Professor of Radiology. When he moved away to become Director of the Department of Radiology at the Germantown Hospital in 1948, he was asked to accept a continuing appointment as Clinical Professor of Radiology. Since this change of status in 1948, Dr. Young has continued to teach, and his weekly Monday afternoon Conferences on Roentgen Diagnosis in the Abdomen, at our Medical School X-ray Museum, are extremely well attended and may be presumed to have had some influence upon his choice of a subject for the Carman Lecture of 1954.



Barton R. Young, M.D.  
Carman Lecturer, 1954

## Roentgen Examination of the Acute Abdomen

The Carman Lecture<sup>1</sup>

BARTON R. YOUNG, M.D.

**T**HIS EVENING marks the twentieth anniversary of the establishment of the Carman lecture by this great Society to honor the memory of one of its distinguished founders and former presidents—Russell D. Carman. The honor of being invited to give this lecture by your President, Dr. Eugene P. Pendergrass, is greatly appreciated, and the obligation of attempting to attain the high standards of previous lecturers is keenly felt.

It was not my privilege to know Russell Carman, but I share your great admiration of him and appreciation of his many fine contributions to Radiology. Previous Carman lecturers have ably furnished us with important biographical information and their splendid essays are recommended, not only for their valuable scientific contributions, but also as sources of knowledge concerning his life and achievements.

The subject under discussion—Roentgen Examination of the Acute Abdomen—was selected because of the great value of this procedure in demonstrating the site and frequently the nature of an acute process, thus enabling prompt and effective treatment. It is a subject that would have appealed to Carman, because of his intense interest in roentgen diagnosis of lesions of the gastrointestinal tract, an area affected by many of the diseases under consideration in this lecture. Roentgen examination has proved so informative in the evaluation of the acute abdomen that many consider it an indispensable part of the diagnostic procedure.

The technic is somewhat varied, depending on the location and the type of disease. Minimal requirements for most abnormalities are postero-anterior, an-

teroposterior, and horizontal-beam lateral decubitus films (Fig. 1). This last is preferred to the erect horizontal-beam examination, because the ill patient is more easily positioned with less exertion. These are the views usually utilized in the examination, but individual problems may require certain additional studies, including the opposite lateral decubitus, conventional lateral, erect, and body-section films. When calculous disease of the biliary tract is suspected, sharply coned films of the gallbladder area with the patient prone should be included in the examination. Stereoscopic anteroposterior views of the urinary tract are obtained when disease is suspected in this area.

Manifestations of numerous acute processes in the abdomen are demonstrable by roentgen examination. Some of these abnormalities are mechanical, paralytic, and vascular occlusive ileus; perforation of a hollow viscus, with escape of air and fluid into the peritoneal cavity or retroperitoneal space; calculous and other diseases of the biliary, urinary, and pancreatic tracts; abscess formation; pelvic disease and, finally, rupture of a solid organ, as the spleen, liver, or kidney.

Ileus is the most frequently found disease process, and determination of its presence, type, and etiology is therefore one of the important functions of roentgen examination of the acute abdomen. At times, it is difficult or impossible to be certain of the type, despite careful correlation of the clinical findings with the roentgen evidence. This is especially true when excess gas and fluid are widely and uniformly distributed in the small and large bowel, without definite evidence of a block. Unless the obstruction is low in

<sup>1</sup> From the Department of Radiology, Germantown Hospital, and Temple University, Philadelphia, Penna. Delivered before the Radiological Society of North America, at the Fortieth Annual Meeting, Los Angeles, Calif., Dec. 7, 1954.

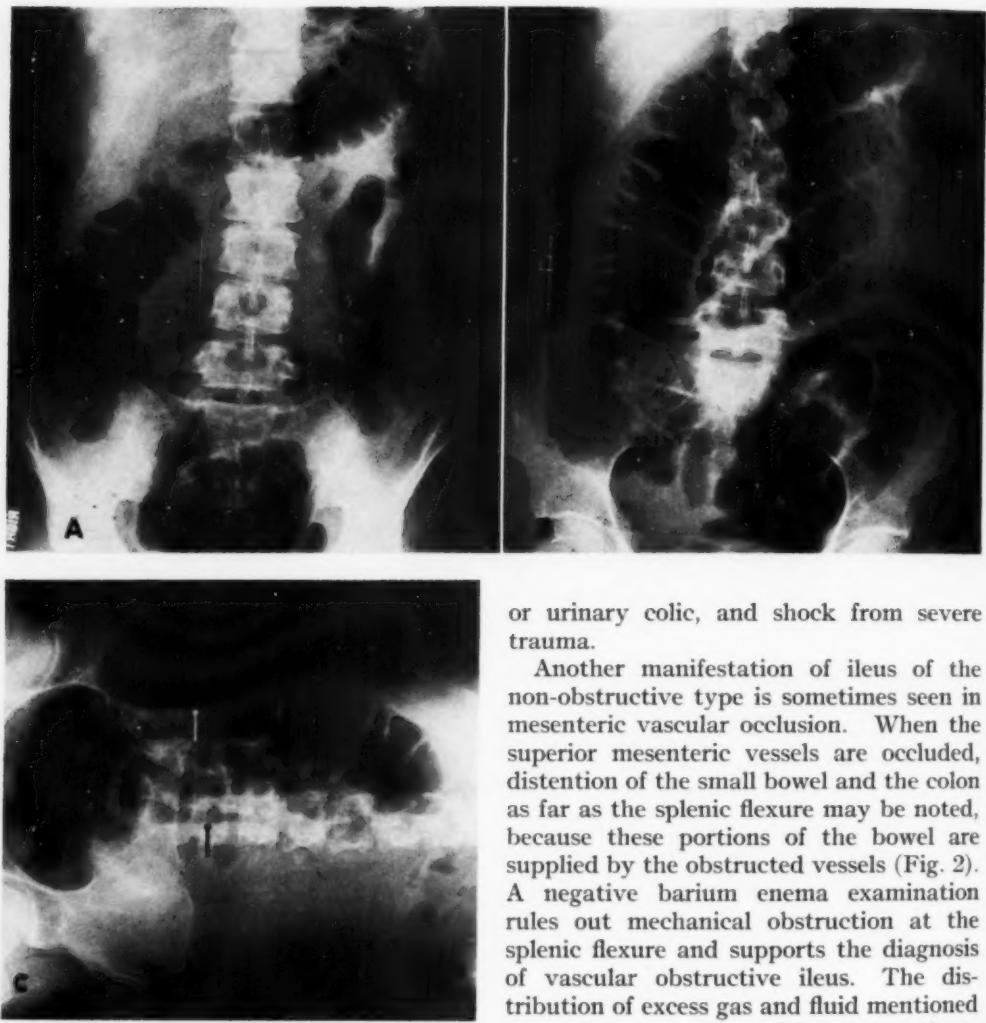


Fig. 1. Paralytic ileus revealed by prone (A) supine (B) and lateral decubitus (C) films four days after removal of a large ovarian cyst. Fluid levels and excess gas in the small bowel and cecum are seen on the lateral decubitus view (arrows). A combination of prone and supine films is far superior to either one of these views alone in demonstration and localization of distended loops, thus permitting better evaluation. The typical appearance of distended valvulae conniventes of small bowel is demonstrated by the supine film (B).

the rectum, such an appearance is usually due to paralytic or adynamic ileus, most commonly found in the postoperative patient (Fig. 1). Paralytic ileus not infrequently follows a cerebrovascular accident, coronary occlusion, acute biliary

or urinary colic, and shock from severe trauma.

Another manifestation of ileus of the non-obstructive type is sometimes seen in mesenteric vascular occlusion. When the superior mesenteric vessels are occluded, distention of the small bowel and the colon as far as the splenic flexure may be noted, because these portions of the bowel are supplied by the obstructed vessels (Fig. 2). A negative barium enema examination rules out mechanical obstruction at the splenic flexure and supports the diagnosis of vascular obstructive ileus. The distribution of excess gas and fluid mentioned above is inconstant, and in some patients a small amount is seen throughout the entire colon.

Regional or segmental ileus is seen in the presence of localized acute inflammatory disease complicated by neighborhood peritonitis, as for example in cholecystitis, pancreatitis, and appendicitis. The site of the ileus suggests the area of primary disease. Therefore, significant distention of a loop of small bowel in the right upper quadrant warrants a tentative diagnosis of cholecystitis, and ileus of a low-lying loop to the right of the mid-line is evidence in favor of appendicitis (Fig. 3). It is

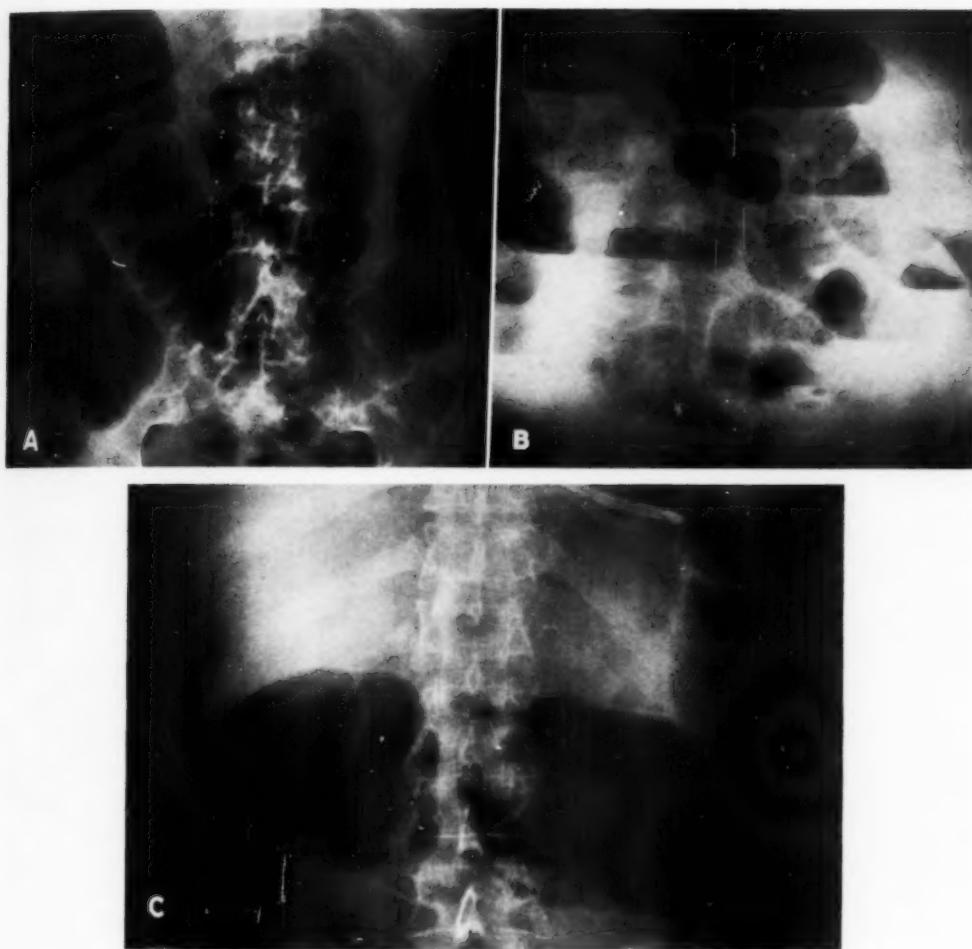


Fig. 2. Vascular occlusive ileus. A and B. Disproportionate distention of small bowel and colon to splenic flexure caused by occlusion of superior mesenteric vessels. Spontaneous massive thrombosis caused death twenty-four hours after sudden onset of severe abdominal pain and distention. C. Marked distention of bowel to splenic flexure attributed to fatal mesenteric vascular occlusion five days after gastrectomy.

often impossible to be certain of the exact site of the disease from this evidence alone, since maximal bowel distention is sometimes seen midway between either the gallbladder and appendix or the pancreas and one of these two structures. As always, the roentgen findings must be correlated with those obtained by clinical examination before an attempt is made to localize the acute inflammatory process. This fact does not lessen the importance of roentgen demonstration of

segmental ileus, since this is often the most conclusive evidence of acute abdominal disease and frequently makes possible its localization. This is true particularly of an enlarged inflamed gallbladder; it is often possible to demonstrate the enlarged viscus surrounded by gas-filled bowel (Figs. 12, C and D; Fig. 13, A and B). The term "sentinel loop" is used to describe focal or regional small bowel distention secondary to acute inflammation of an abdominal viscus.

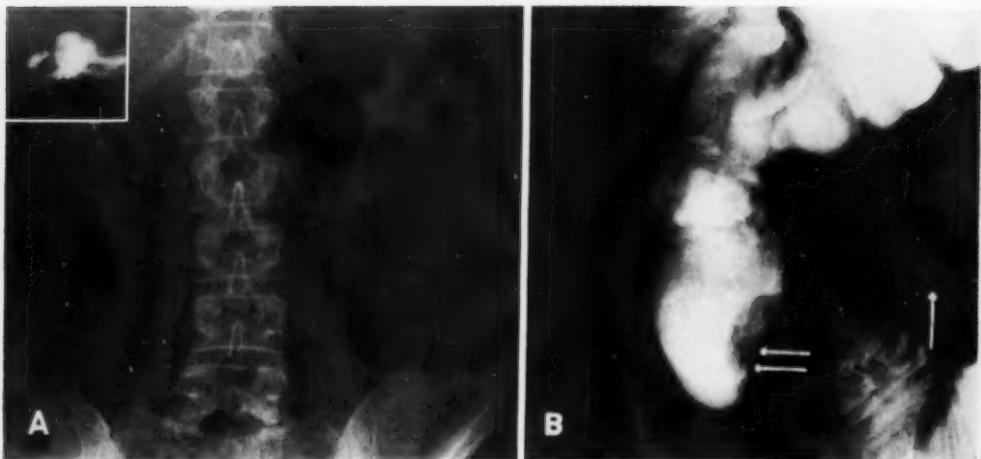


Fig. 3. A. Regional paralytic ileus secondary to acute cholecystitis (arrow). Failure of concentration of gallbladder medium was substantiating evidence. Fistulous tract from gallbladder to duodenum and enlarged acutely inflamed gallbladder found at surgery (insert). B. Segmental ileus secondary to appendicitis and localized peritonitis (arrow). Sentinel loops noted on preliminary film and appendiceal abscess revealed by barium enema (arrows).

Mechanical obstruction of the small intestine results in distention of loops of bowel by gas and fluid (Fig. 4). Lateral decubitus or erect films obtained with a horizontal beam reveal fluid levels, with gas above the fluid and ribbing or ring-like striations produced by the stretched valvulae conniventes (Fig. 4, C and D). It is this appearance or the stepladder-like configuration that differentiates the distended small bowel from the dilated colon, with its typical haustral markings (Fig. 1B). The approximate site of the block is predicted from the location of the dilated loops. Thus, if distended small bowel is seen in the pelvis or in the right lower quadrant, the obstruction is probably in the lower ileum or proximal colon. It is important to emphasize that the site of obstruction is often lower than the most distal fluid level. The presence of abnormal homogeneous opacity below the lowermost fluid level indicates that the obstructed loops are filled with fluid (Fig. 4D). The fluid-filled loops are similar in density to a neoplasm, and for that reason the term "pseudo-tumor" is sometimes used to designate them. When doubt exists about the level of obstruction, a barium enema study is indicated to

rule out or establish colonic obstruction.

Mechanical obstruction of the small bowel is frequently caused by adhesions and less commonly by localized collections or abscesses in the peritoneal cavity. Other causes are inflammatory and intraluminal disease, internal and external hernias, foreign bodies, including biliary calculi, and tumors, either intrinsic or extrinsic. Early or partial mechanical small bowel obstruction is often more difficult to diagnose with certainty (Fig. 4, A and B). When the findings are equivocal and the symptoms persist, another examination should be done in from four to twelve hours, since initial indeterminate findings may become full blown, with possible serious consequences if unrecognized. The clinical course of the disease should be closely followed, and the patient re-examined to determine progression or regression of the obstructive process (Fig. 4).

Strangulation of the small intestine occurs when a loop is incarcerated or twisted, causing partial or complete closure of the lumen and interference with the blood supply. Adhesions, volvulus, and herniation of a loop through a normal or abnormal opening are etiologic factors. Preliminary films reveal disproportionate distention of

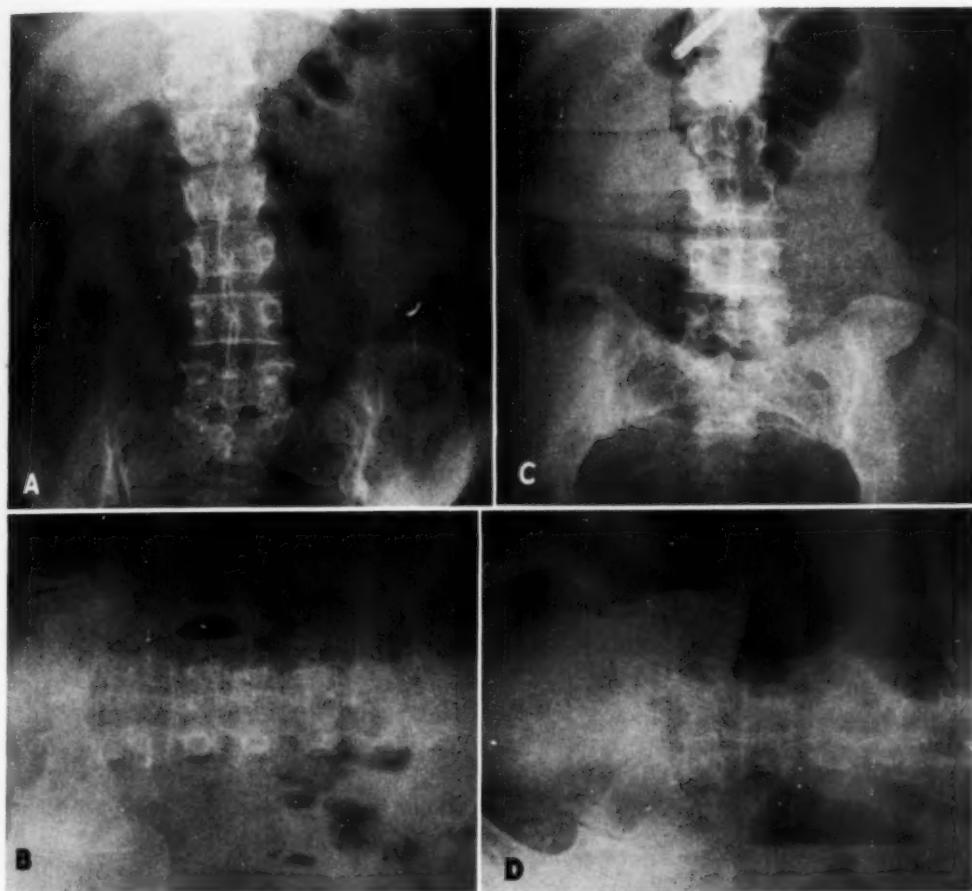


Fig. 4. Mechanical small bowel obstruction, showing value of follow-up examination. Partial obstruction demonstrated by initial study (A and B). Obstruction complete thirty hours later (C and D). Both examinations reveal significant fluid in pelvic small bowel below level of gas. Obstruction due to adhesions from previous operation revealed at surgery. Homogeneous increased opacity in pelvis is due to fluid-filled loops of small intestine or so-called "pseudo-tumor" (C and D).

the involved loops by either gas or fluid. The distended loops are often parallel or U-shaped, with a dividing line of increased density produced by either fluid or apposing bowel walls.

Complete closure of the proximal loop prevents the entrance of gas, and thus only fluid is trapped in the strangulated bowel, resulting in homogeneous increased density or the so-called "pseudo-tumor" sign previously mentioned. In incomplete closure, two fluid levels are seen if the loops are parallel, and they present the above-described configuration. Occasionally a long fluid level is demonstrated in the

obstructed segment. Fixation of trapped loops, revealed by lack of movement, despite change in position of the patient, is a valuable sign of strangulation. Of lesser value in the diagnosis is flattening of the mucosal folds, indicating marked distention and inability to decompress a localized distended segment by intubation (7).

Intestinal obstruction in the newborn and in early infancy is nearly always due to congenital anomalies, particularly atresias and stenoses (1, 2). The approximate site of the obstruction is revealed by film studies that show distended bowel above the block and collapsed intestine below

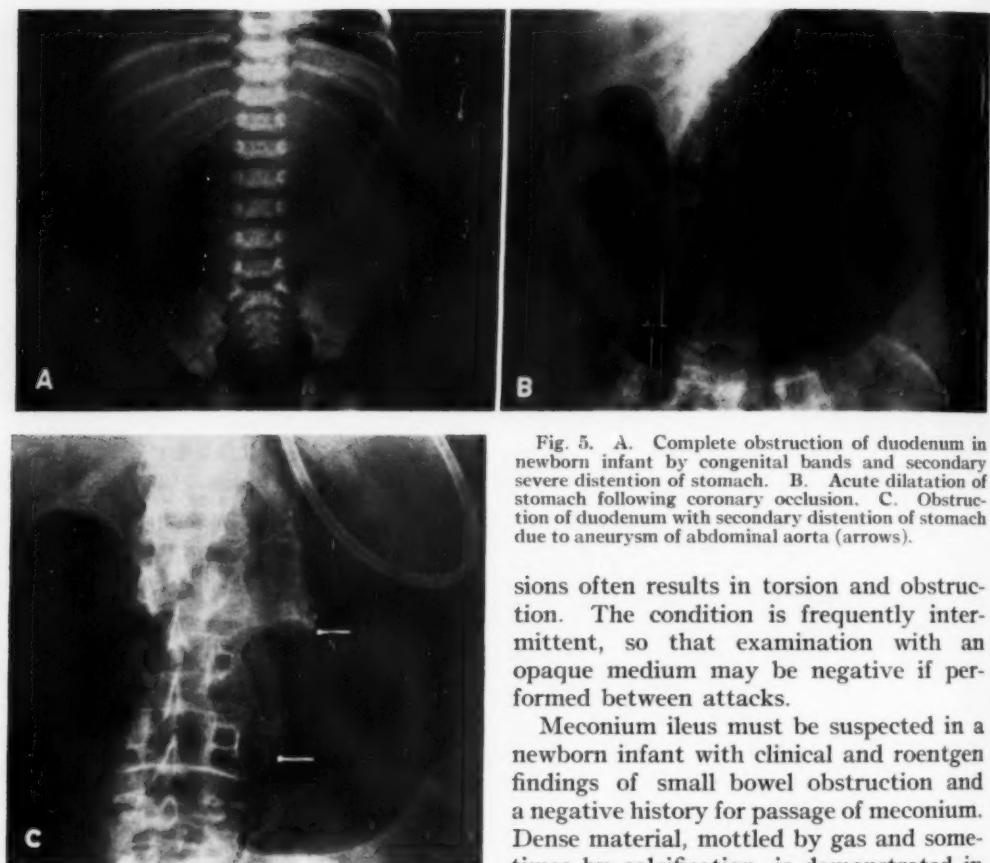


Fig. 5. A. Complete obstruction of duodenum in newborn infant by congenital bands and secondary severe distention of stomach. B. Acute dilatation of stomach following coronary occlusion. C. Obstruction of duodenum with secondary distention of stomach due to aneurysm of abdominal aorta (arrows).

sions often results in torsion and obstruction. The condition is frequently intermittent, so that examination with an opaque medium may be negative if performed between attacks.

Meconium ileus must be suspected in a newborn infant with clinical and roentgen findings of small bowel obstruction and a negative history for passage of meconium. Dense material, mottled by gas and sometimes by calcification, is demonstrated in the dilated bowel above the block. The colon is contracted in contrast to the dilated small intestine (Fig. 6), which is filled with tenacious, mucilaginous meconium that is extremely difficult to remove surgically. Fibrocystic disease of the pancreas is a frequently associated finding, and roentgen examination of the chest is therefore indicated to determine pulmonary emphysema. Meconium peritonitis is due to extrusion of meconium through a rupture of the bowel. It occurs during the last months of fetal life and in the newborn. The roentgen diagnosis is made by the demonstration of free air and irregularly distributed calcifications in the peritoneal cavity (Fig. 6). Small bowel obstruction and a smaller than average colon are additional important findings. Congenital atresia is a frequent cause of rupture, and

it. Distention of both the stomach and the duodenum in an infant is usually due to congenital bands, stenosis, or atresia (Fig. 5A). In the adult, acute dilatation of the stomach has a reflex and mechanical basis. It has occurred reflexly following coronary occlusion and also after application of a body cast (Fig. 5B). If the condition is unrecognized and untreated, rupture of the stomach and death from peritonitis are possibilities. An unusual cause of mechanical duodenal and gastric obstruction seen recently was an aneurysm of the aorta compressing the third portion of the duodenum (Fig. 5C).

In children, obstruction of a loop of small bowel is sometimes due to volvulus, predisposed to by failure of rotation. This anomaly plus congenital bands or adhe-

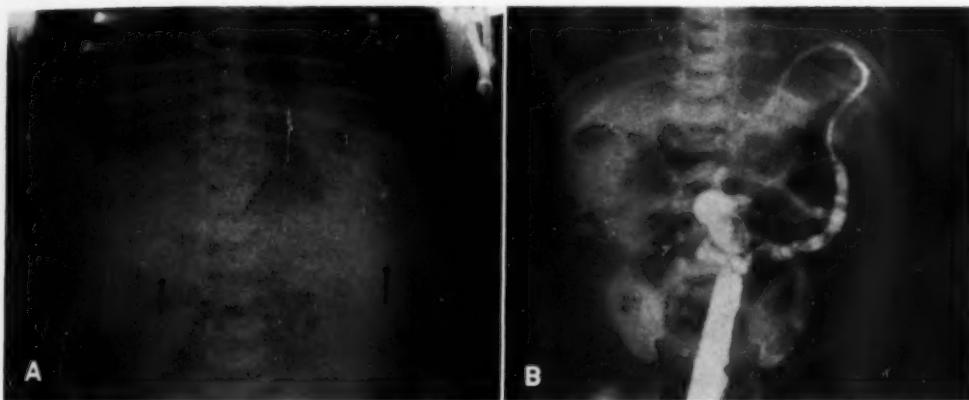


Fig. 6. Meconium ileus and peritonitis. One large and multiple small calcific plaques are distributed irregularly in the peritoneal cavity, due to rupture of bowel and discharge of meconium (A, arrows). Free air indicates rupture of bowel (A and B). Small size of colon revealed by barium enema (B).

meconium ileus is probably a precursor in some cases.

Acute intussusception may produce complete obstruction of either the small or large bowel, in which event the findings are those of obstruction described previously, namely, excess gas and fluid in the bowel proximal to the block. In the absence of complications, obstruction due to this cause is uncommon, but in a recent series of 42 children, 5 of 7 with complications showed small bowel obstruction (6). When the small bowel is intussuscepted into the cecum and ascending colon, preliminary films may reveal exclusion of gas from the right side of the colon, and excess gas in the small bowel proximal to the portion that is intussuscepted. Occasionally, there is enough gas in the cecum and ascending colon to outline the intussuscepted ileum. Introduction of a barium sulfate suspension into the colon, by enema, outlines characteristic ring-like shadows of the intussuscepted portion of the bowel and a concavity in the shadow of the advancing barium mixture, produced by the invaginated portion (Fig. 7). The barium often pushes the intussuscepted bowel ahead of it, thus effecting reduction. Intussusception is occasionally due to a tumor or diverticulum that pulls the bowel with it as it is moved forward by peristaltic action. A more unusual cause was a

large laminated gallstone that became wedged in the upper sigmoid during its passage through the intestine after it had ulcerated into the small bowel from the gallbladder (Fig. 7, B and C). Sometimes sufficient gas is present in the intussuscepted bowel for visualization of a tumor or other space-occupying disease. Lipoma causing intussusception is often demonstrable on plain films because the tumor is radiolucent.

Paraduodenal or retroperitoneal hernia is an uncommon cause of intestinal obstruction in childhood. The roentgen findings are absence of loops of small bowel in the pelvis when the patient is erect, a collection of distended loops of small bowel that appear to be in a sac to either the right or left of the mid-line at the level of the duodenum, delayed transit time of opaque material through the involved loops, and upward displacement of the greater curvature of the stomach if the hernia is left-sided. Retroperitoneal hernia of the small intestine through an opening in the mesentery, through the fossae about the cecum, and through the lesser peritoneal sac rarely occurs but must be considered when films show excess gas in loops of small bowel, especially when the coils are closely bunched in abnormal positions.

Acute abdominal pain occurs in regional

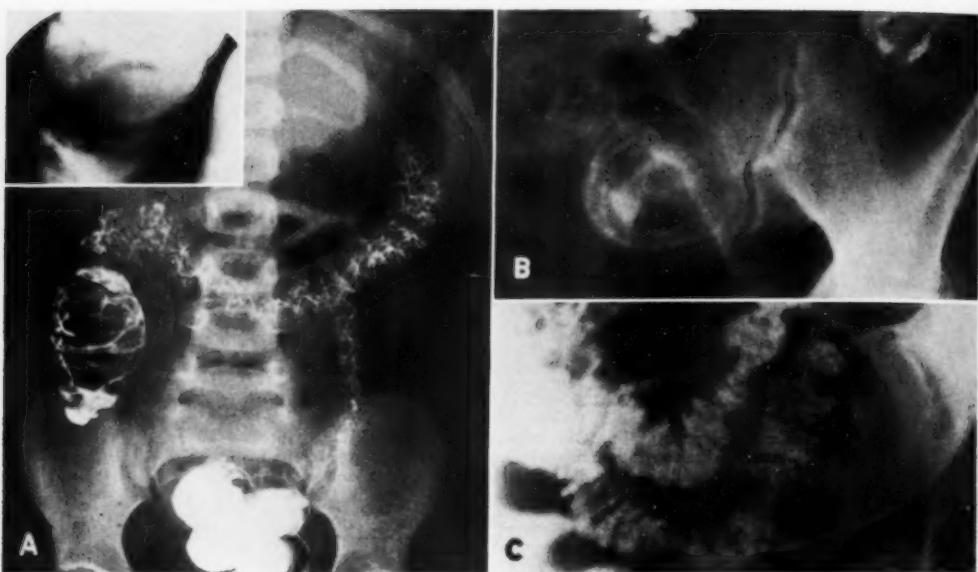


Fig. 7. Acute ileocecal intussusception. A. Intussusception of lower ileum into cecum, unreduced by barium enema. Characteristic ring shadows seen on filled (insert) and post-evacuation films. B and C (courtesy Dr. M. F. Goldsmith, Pittsburgh, Penna.). Large laminated gallstone in sigmoid, causing intussusception.

enteritis following ingestion of food, particularly when the bowel is stenotic. The pain is crampy in character and is usually associated with diarrhea. Plain-film examination rarely demonstrates abnormality unless the disease is advanced, but oral administration of a barium-water mixture reveals narrowing of involved segments of the small bowel and disturbance in motor function. When stenosis is severe, there is marked delay in the transit time. One or more stenotic areas with relatively unininvolved zones between may be demonstrated by small bowel study. In idiopathic steatorrhea or non-tropical sprue, acute cramping abdominal pain associated with watery diarrhea is not uncommon. Although the acute abdominal pain is sometimes sufficiently severe to suggest the necessity of emergency treatment, a careful history usually indicates previous similar bouts, with foul stools containing a high excess of fatty material and, therefore, necessity of further study.

A diagnosis of obstruction of the colon is indicated when plain films reveal excess gas and fluid in both the small and large

bowel and an abrupt termination of the gas shadow in the colon (Fig. 8). Despite such clear-cut evidence, a barium enema is indicated for better definition of the obstructive lesion, and also to rule out a second lesion. Great care should be exercised in the barium enema study, since complete obstruction may occur if the opaque material is trapped above the stenotic area. The principal causes of obstructive disease of the colon are carcinoma and diverticulitis.

Volvulus of the colon should be suspected when plain films show tremendous distention to the point of effacement of the haustral markings of the involved bowel. There is a high incidence of elongation of the bowel and mobility of the mesentery, and the obstructed loop, therefore, often migrates far from its original site. In volvulus of the cecum and ascending colon, preliminary films reveal extreme distention of the right colon by gas and fluid with one or two fluid levels in the involved areas. The small bowel shows significant but less distention, and the colon distal to the obstruction contains

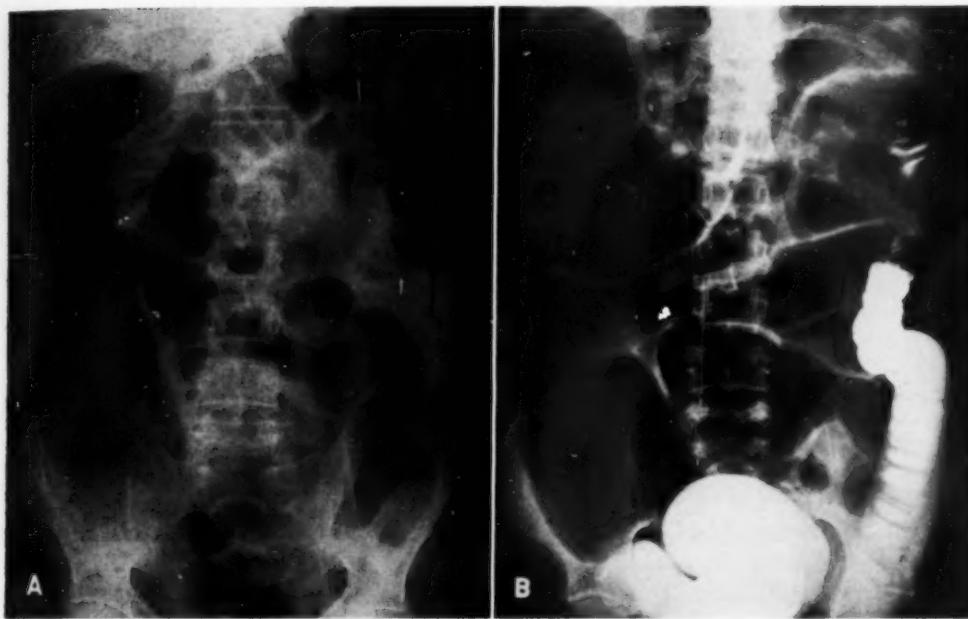


Fig. 8. A. Preliminary film showing complete obstruction of mid-descending colon by carcinoma (arrow). Colon proximal to obstruction and small bowel are markedly distended. B. Barium enema demonstrates stenotic lesion.

little or no gas unless the block is incomplete. Marked right colon distention is the outstanding roentgen finding, but the diagnosis is difficult because of migration of the cecum to an unusual location, often in the left upper quadrant (3) (Fig. 9A). In this position, the medial contours of the distended cecum are directed toward the patient's right, due to 180 degrees rotation. Occasionally, it is possible to visualize the tapered appearance of the bowel as it enters the volvulus (Fig. 9A). When the obstruction is incomplete, the diagnosis is difficult from plain films and a barium enema is indicated. The area of torsion is frequently demonstrated by the enema study (Fig. 9A, insert).

Clinical suspicion of volvulus of the sigmoid necessitates roentgen examination because this allows early diagnosis. Plain films reveal bowel obstruction and in some cases indicate the nature and approximate location of the block. Greatly distended loops of sigmoid rise out of the pelvis to the mid-abdomen and as high as the diaphragmatic level (Figs. 9B and C). Two

fluid levels may be visualized if the obstruction is of the closed-loop type, and both ends of the obstructed loop are occasionally seen if sufficient gas is trapped. A barium enema is usually necessary to demonstrate the zone of torsion, manifested by pathognomonic corkscrew parallel alternate bands of increased and diminished density (Fig. 9B, insert). The barium column is rounded or tapered in appearance if the obstruction is complete.

Free air in the acute abdomen is often due to ruptured peptic ulcer. Less common causes are perforation of the intestine by a foreign body or tumor, rupture or perforation of a diverticulum, tear due to instrumentation as in distention of the rectum by a Bardex during a barium enema examination, and, in infancy, rupture due to atresia (Figs. 6 and 10). Recent laparotomy, injection of air or gas, and introduction of a needle for paracentesis must be ruled out before a diagnosis of perforation of a hollow viscus is made. Either lateral decubitus or erect film studies are necessary to show extraluminal gas be-

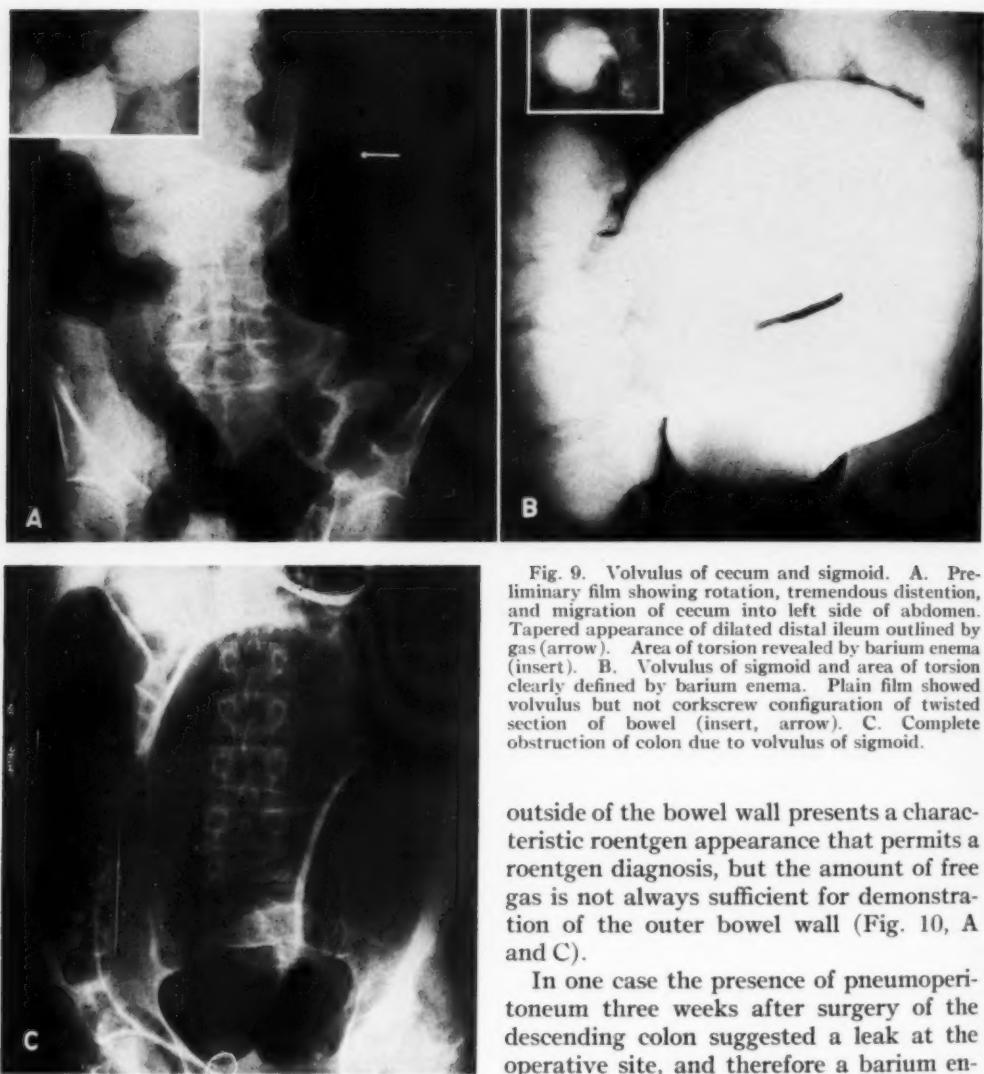


Fig. 9. Volvulus of cecum and sigmoid. A. Preliminary film showing rotation, tremendous distention, and migration of cecum into left side of abdomen. Tapered appearance of dilated distal ileum outlined by gas (arrow). Area of torsion revealed by barium enema (insert). B. Volvulus of sigmoid and area of torsion clearly defined by barium enema. Plain film showed volvulus but not corkscrew configuration of twisted section of bowel (insert, arrow). C. Complete obstruction of colon due to volvulus of sigmoid.

outside of the bowel wall presents a characteristic roentgen appearance that permits a roentgen diagnosis, but the amount of free gas is not always sufficient for demonstration of the outer bowel wall (Fig. 10, A and C).

In one case the presence of pneumoperitoneum three weeks after surgery of the descending colon suggested a leak at the operative site, and therefore a barium enema was done, with positive findings (Fig. 10, A and B). In another patient, a large amount of gas escaped from a perforated colonic cancer, causing distention of the abdomen. Loops of distended small bowel are thrown into relief by gas around them (Fig. 10C). Retroperitoneal free gas is more difficult to diagnose, but the presence of linear radiolucent streaks behind the liver warrants consideration of rupture of a retrocecal appendix and perforation of the rectum (Fig. 11C, D, and E). Rarely the same picture is seen

neath the highest portion of the peritoneal cavity. It is not always possible to demonstrate free air, perhaps due to early sealing off of the perforation, but as little as 2 c.c. of air injected through the anterior abdominal wall has been visualized beneath the diaphragm in an erect subject, after a twenty-minute wait (5). The lateral decubitus position is preferred because it requires less manipulation of the patient and affords a greater incidence of demonstration of free air. Gas inside and

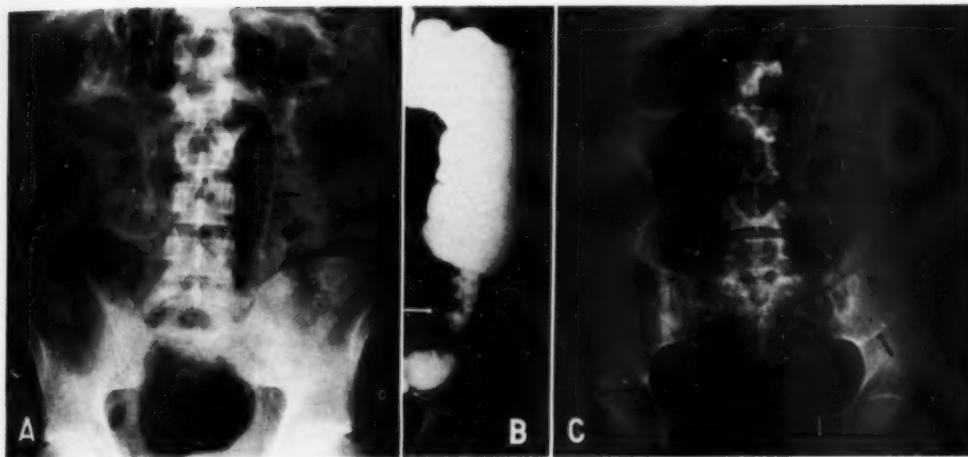


Fig. 10. Demonstration of outer surface of intestine indicates free air in peritoneal cavity (A and C, arrows). Preliminary films show distention of bowel and both serosal and mucosal surfaces of small intestine, warranting diagnosis of free air. Barium enema shows stenosis and leak at anastomosis (B, arrow). Large quantity of free air from perforated colonic cancer and excess intraluminal gas make possible excellent visualization of both inside and outside of distended small intestine (C, arrows).

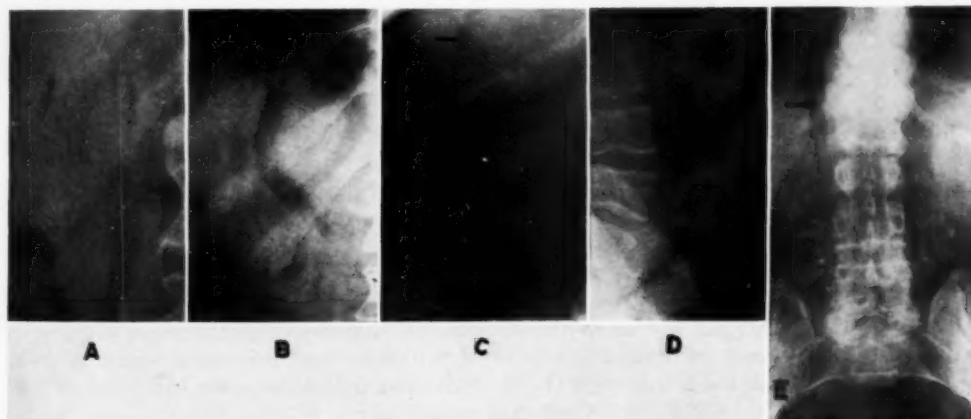


Fig. 11. Differential appearance of gas in biliary tract and retroperitoneal space. A. Gas in biliary tract secondary to destruction of ampulla of Vater by carcinoma. B. Common duct visualization by gas ascending through choledochoduodenal fistula caused by perforating ulcer. C. Irregular retroperitoneal gas collections from ruptured retrocecal appendix (arrows). D. Perforation of rectum by inflated Bardex. Note linear collections of gas in pelvis to either side of spine and beneath diaphragm (arrows).

following surgery of the colon and biliary tract complicated by postoperative infection.

Gas in the lumen of either the gallbladder or biliary tract usually indicates an abnormal communication with the intestine, most frequently caused by erosion of a gallstone into the intestinal tract. The resulting fistula allows gas to pass into the biliary tract, and rarely into the pancreatic

ducts. Previous anastomosis of the gallbladder or common duct to the intestine permits gas to ascend into these areas, and for this reason a careful history is important. Carcinoma of the ampulla, perforation of a gastric or duodenal ulcer, and pancreatitis are less common causes of gas in the biliary tract (Fig. 11, A and B).

Emphysema of the gallbladder is due to severe infection by gas-producing organ-

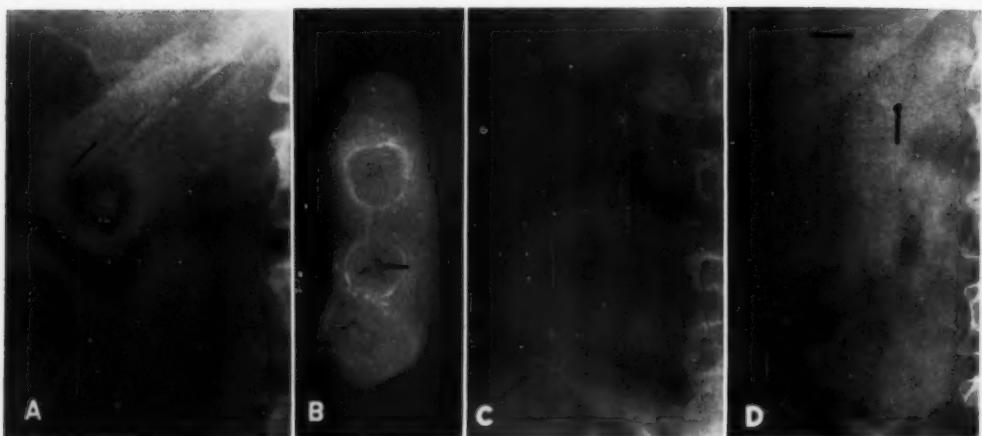


Fig. 12. Gallstones and enlarged gallbladder diagnosed on preliminary films. A and B. Stellate radiolucencies (arrows) indicate gas-containing stones in gallbladder, thus enabling diagnosis on plain films. C. Widely separated laminated stones in a huge gallbladder (arrows). Lack of movement of superior stone indicates impaction in neck. D. Greatly enlarged gallbladder outlined at inferior margin by gas in colon. Large, poorly opaque stones are widely separated except those impacted in neck (arrows).

isms that form bubbles of gas in its wall and in the pericolic tissues (8). Many patients with this condition are diabetic, and surgery reveals gangrene of the gallbladder wall. Emphysema must be differentiated not only from gas in the lumen of the gallbladder and biliary tract as a result of a fistula, but also from gas behind the liver, in the retroperitoneal cavity. The appearance of emphysema of the gallbladder is rather characteristic because the collections of gas conform to the shape of the viscus, since they are in its wall. In fistula, the gas is in the lumen only.

Calculus disease of the biliary tract is one of the common causes of acute abdominal distress. Less than one-fifth of gallstones contain enough calcium for demonstration on plain-film examination, but a careful search for opaque calculi and gas-containing stones is often rewarding. Characteristic stellate or linear radiolucencies in the gallbladder area indicate gas in stones (Fig. 12, A and B). Wide separation and excursion of such radiolucent areas, or of calcified stones, on change of position of the patient is ample evidence of a greatly enlarged gallbladder (Fig. 12, C and D).

It is often possible to make a diagnosis of

an enlarged gallbladder on the plain film because of increased opacity of the distended viscus; in fact, this diagnosis has been made and verified by surgery many times (8). The inferior margin of the gallbladder is sometimes outlined by gas in adjacent bowel (Figs. 12, C and D, and 13, A and B). Rarely an enlarged kidney is marginated inferiorly by the colon and thus has the appearance of a hydropic gallbladder (Fig. 13C). Infrequently an enlarged gallbladder simulates the kidney, in which event excretory urography is indicated for differentiation (Fig. 13, A and B).

Acute abdominal symptoms referable to the urinary tract are also often produced by calculus disease. As indicated previously, stereoscopic anteroposterior films should be obtained when urinary calculus is suspected. Demonstration of an opaque calculus is usually possible by preliminary films, but if these are negative, excretory urography should be done immediately to determine function and obstruction. Other abnormalities of the urinary tract are usually revealed by urography. Abnormal position of the kidney and variation in its size, due to infection, cyst or tumor, are demonstrable by either plain-film examina-

tion or excretory urography (Fig. 13C). In polycystic disease of the kidneys, episodes of acute abdominal pain are less common than chronic dull aching pain, but they do occur, especially following hemorrhage into the cyst. Clots from the hemorrhage occasionally produce transient ob-

struction, when this condition is suspected, immediate surgery is done and no opportunity is afforded to visualize the tear in the bladder by contrast studies.

Rupture of the spleen must be suspected when films reveal enlargement of that organ or irregularity in its contour. Hemorrhage

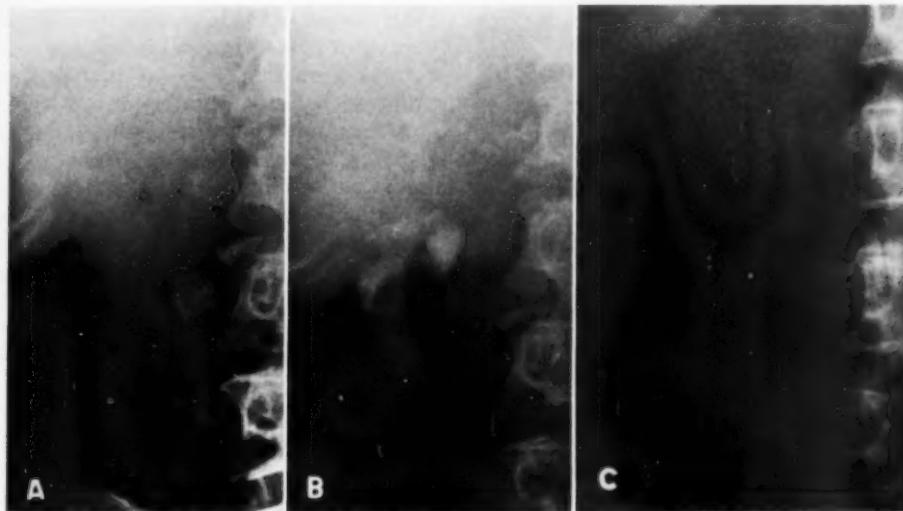


Fig. 13. Differentiation of enlarged gallbladder and pyonephrotic kidney. A. Enlarged gallbladder having appearance of right kidney. B. Excretory urography proves shadow is gallbladder. C. Enlarged pyonephrotic kidney simulates hydropic gallbladder, but at surgery gallbladder was normal and kidney was greatly enlarged (arrow).

struction of the ureter and colic results. The symptoms of urinary tract disease are nearly always unilateral. Renal carbuncle produces unilateral aching pain with fever and leukocytosis. Roentgen examination reveals enlargement if it is appreciable, but contrast studies are necessary in order to determine the underlying etiology (Fig. 13C). Rupture of the kidney, either spontaneous or due to acute trauma, can be demonstrated if there is appreciable separation and distortion of the pelvicalyceal system. Preliminary film examination may show renal enlargement, obliteration of the kidney margin, irregularity in its contour, or effacement of the psoas muscle shadows, but urography is usually necessary to determine the extent of damage (4).

Rupture of the urinary bladder causes diffuse abdominal pain but cannot be diagnosed by plain-film examination.

into the perisplenic tissues or abdominal cavity produces increased density. Displacement of the diaphragm, splenic flexure and stomach, fractured ribs, and reflex dilatation of the stomach are additional valuable roentgen findings that suggest the diagnosis (9).

In acute pancreatitis, the plain-film examination may show excess gas in an adjacent loop of small bowel, if there is an associated peritonitis. The appearance of the dilated sentinel loop is rather characteristic, and its proximity to the pancreas suggests the diagnosis. Pancreatic lithiasis, either with one or more stones in the duct system or diffuse calcification throughout the gland, is demonstrable by preliminary films (Fig. 14). Deformity and displacement of the duodenum by a carcinoma or cyst of the pancreas are usually not apparent unless barium sulfate is given orally,



Fig. 14. Diffuse pancreatic lithiasis and cystic enlargement of the head of the pancreas. Calcific concretions are noted in the main ducts and in the common duct, besides diffuse calcification elsewhere. Marked widening of the duodenal loop is due to a huge cyst in the head of the pancreas, visualized by a small amount of barium and air. Previously patient had sympathectomy in an attempt to relieve intractable pain.

except in the case of a very large tumor that produces abnormal opacity and a marked space-taking effect (Fig. 14).

Roentgen diagnosis of subdiaphragmatic abscess is difficult unless the organisms form gas and there is an air-fluid level beneath the diaphragm demonstrated by lateral decubitus or erect film examination. When a subdiaphragmatic collection is suspected, the film study should include the lower portion of the chest, in order to determine whether the diaphragm is obliterated by an effusion and elevated by the pus beneath it. Fluoroscopy is also important to demonstrate limitation of movement on the involved side. Occasionally, the collection is sufficient to displace adjacent intestine and increase the size of the liver. The pulmonary manifestations may include compression or discoid atelectasis due to elevation and lack of excursion of the diaphragm. A pelvic or appendiceal abscess may produce sufficient opacity or deformity of the bowel to suggest its presence either on plain-film examination or barium studies (Fig. 3B).

A twisted pedicle of an ovarian cyst produces acute abdominal pain. Plain films

may reveal abnormal, sharply marginated increased density if the cyst is of appreciable size. Dermoids often contain an oily or fatty substance that produces a radio-lucent shadow, usually definitely circumscribed. Fragments of teeth or calcific material in the ovarian region indicate a dermoid.

Herniation of the intestine either through the diaphragm or one of its openings such as the inguinal or femoral ring produces symptoms if the bowel is obstructed. Since traumatic rupture of the diaphragm results in evisceration of some of the abdominal structures into the chest, examination should also include the lower half of the thorax.

Acute cramp-like abdominal pain simulating the clinical picture of an acute surgical emergency occurs in acute porphyria. This disease is one of abnormal pigment metabolism with excessive production of porphyrins that act on the central nervous system and the nerve supply to the cardiovascular system and gastrointestinal tract. In the latter area, the effect is upon the autonomic nervous system, resulting in distention of small bowel and an abnormal pattern. Abdominal films show marked distention of the loops of small intestine. The clue to the disease is obtained by study of the urine that darkens on exposure to light, which changes porphyrinogen to coproporphyrin. Ultraviolet light causes a pink fluorescence of the urine.

Henoch's purpura occasionally produces segmentation and dilatation of the small bowel as a result of pathologic bleeding, due in turn to increased vascular permeability. Hemorrhages occur within the mucosal and submucosal layers of the intestinal walls. Cramping abdominal pain results from hemorrhage into the walls of the intestine and may precede the skin rash.

A dissecting aneurysm of the abdominal aorta produces acute agonizing pain, usually radiating to the back. If there is appreciable shock, reflex ileus may be demonstrated by abdominal film examination. The clue to the underlying etiology

may be obtained if there is calcium in the aneurysmal walls. Not infrequently, it is possible to demonstrate an aneurysm of the abdominal aorta by plain-film examination, which should include a lateral as well as stereoscopic anteroposterior views. As indicated previously, mechanical obstruction of the alimentary tract due to pressure of the sac occasionally occurs but is much less common than reflex ileus (Fig. 5C).

#### CONCLUSIONS

Roentgen examination of the abdomen reveals manifestations of many acute abnormalities and therefore it is an invaluable aid in their recognition and evaluation. It is of great value in demonstrating the site and frequently the character of the acute process, thus enabling prompt and effective treatment. This information is often made available by plain-film examination, but a contrast medium is occasionally necessary.

The roentgen findings in many acute abdominal conditions are discussed, including mechanical, vascular and paralytic ileus; volvulus; intussusception; external and internal hernia; perforation of a hollow viscus, with resultant gas in the peri-

toneal or retroperitoneal spaces; calcinous disease, and inflammatory, cystic, and neoplastic enlargements of the gallbladder, pancreas, and kidney; appendiceal, pelvic, and subdiaphragmatic abscess; rupture of the kidney and spleen.

Germantown Hospital  
Philadelphia 44, Penna.

#### REFERENCES

1. CRAIG, R. M., HODGSON, J. R., AND DOCKERTY, M. B.: Obstruction of the Small Intestine in Infants and Children. A Roentgenologic and Pathologic Study. *Am. J. Roentgenol.* **72**: 412-425, September 1954.
2. DOLIN, S., MATHEWS, H. H., AND RUSSO, P. E.: Congenital Obstruction of the Duodenum and Mal-rotation of the Colon. *Radiology* **63**: 85-90, July 1954.
3. FRIMMANN-DAHL, J.: Volvulus of the Right Colon. *Acta radiol.* **41**: 141-155, February 1954.
4. HALL, M. R.: Traumatic Rupture of the Kidney. *Radiology* **63**: 230-233, August 1954.
5. HODGES, P. C., AND MILLER, R. E.: Intestinal Obstruction. Submitted for publication, *Am. J. Roentgenol.*
6. LING, J. T.: Intussusception in Infants and Children with Emphasis on the Recognition of Cases with Complications. *Radiology* **62**: 505-513, April 1954.
7. MELLINS, H. Z., AND RIGLER, L. G.: Roentgen Findings in Strangulating Obstructions of the Small Intestine. *Am. J. Roentgenol.* **71**: 404-414, March 1954.
8. SCANLAN, R. L., AND YOUNG, B. R.: Roentgen Diagnosis of Gallbladder and Biliary Tract Disease Without Cholecystography. *Am. J. Roentgenol.* **72**: 639-643, October 1954.
9. WYMAN, A. C.: Traumatic Rupture of the Spleen. *Am. J. Roentgenol.* **72**: 51-63, July 1954.

#### SUMARIO

#### Conferencia Carman: El Examen Roentgenológico en los Procesos Agudos del Abdomen

El examen roentgenológico del abdomen revela manifestaciones de muchas anomalías agudas y por lo tanto es de valor insuperable para reconocerlas y justificarlas. También es de mucho valor para descubrir el asiento y frecuentemente la naturaleza del proceso agudo, permitiendo así el tratamiento rápido y eficaz. Esta información la ofrece a menudo el examen con las radiografías corrientes, pero de vez en cuando se necesita un medio de contraste.

Discútense los hallazgos roentgenológicos en muchas afecciones abdominales agudas, comprendiendo fleo mecánico, vascular y paralítico; invaginación; hernia externa e interna; perforación de una víscera hueca, con el consiguiente gas en los espacios peritoneal y retroperitoneal; litiasis y dilataciones inflamatorias, quísticas y neoplásicas de la vesícula biliar, del páncreas y del riñón; abscesos apendiculares, pélvianos y subdiafragmáticos; rotura del riñón y del bazo.

## Cinefluorographic Analysis of the Mechanism of Swallowing<sup>1</sup>

G. H. RAMSEY, M.D., J. S. WATSON, M.D., R. GRAMIAK, M.D., and S. A. WEINBERG

**I**N THEIR WORK on the swallowing mechanism, the early investigators can at least be said not to have overlooked the anatomical probabilities. They found it logical to assume, for instance, that each of the mobile structures and muscles along the upper food channel must necessarily play an active part in the mechanism—"the uppermost first, and then according to their station." This broad assumption, by the way, has never been successfully disputed, and it gives to the rather speculative views of 18th century authorities such as Boerhaave (1) and Haller (2) a comprehensiveness not always evident in more recent work on the subject. Even comprehensiveness, however, can be overdone, as in Boerhaave's over-elaborate and confusing explanation of laryngeal airway protection.

The experimental physiologist Magendie (1783-1855) did much to clarify and give perspective to the older views. We know that he first became interested in the problem while he was still an aide in anatomy at the Paris Faculty, and that his thesis for the medical degree in 1808 was concerned with the functions of the soft palate (3). Later he showed by a series of animal experiments that, although the epiglottis turns "downward and backward" in the second stage of swallowing, "so as to protect the entrance of the larynx," its action is in reality only a first line of defense, since the laryngeal airway is closed with "great exactness," at a lower level, "by the same muscles which control the glottis in the production of the voice."

The paragraphs on deglutition in Magendie's *Physiology* (4) are important, not only because of his famous division of the mechanism into three stages (as compared with Boerhaave's five), but because he succeeds in enumerating nearly all of the

major events of the sequence much as we think we know them today. Several items have since been added, notably the part played by the cricopharyngeus muscle and some of the particulars of reflex control, but nothing has been subtracted. Indeed, it can be argued that subsequent investigation has only confirmed and filled in the details of Magendie's original outline.

In the latter part of the 19th century, the mechanism of swallowing, and especially of the esophageal stage, was carefully restudied in rabbits and in man with the aid of the stethoscope, stomach tube, and pressure balloon. Kronecker and Meltzer (5) amplified Magendie's remarks about the swallowing of liquids by stating that they are squirted through the pharynx and esophagus so fast as apparently to leave the peristaltic wave of contraction far behind. It remained for x-ray methods to show that in the pharynx the contraction wave actually follows in close contact with the tail of the liquid.

Fluoroscopy and the bismuth swallow were first used in this field by Cannon (6), on a suggestion made by Bowditch in 1896. Cannon anticipated that fluoroscopy would give more information about the esophageal stage of swallowing than about the pharyngeal stage, and in this he was correct. However, in 1927 Mosher, a laryngologist, used x-ray methods to confirm and amplify Magendie's account of the behavior of the hyoid bone, epiglottis, and larynx, illustrating his paper with films taken by the radiologist Macmillan (7).

Meanwhile Barclay was already working on his well known fluoroscopic study of swallowing. Unfortunately he did not hear of the studies of Mosher and Macmillan until after his first report had been nearly completed and he mentions their work only to dismiss it as being no differ-

<sup>1</sup> From the Department of Radiology, University of Rochester School of Medicine and Dentistry, Rochester, New York. Presented at the Seventh International Congress of Radiology, Copenhagen, July 19-24, 1953.

ent from the textbooks (8 and 9). Barclay's account of what he saw on the fluoroscopic screen is undoubtedly one of the most fascinating descriptions of its kind in the literature, and no less fascinating because of his errors of fact. He denied that the epiglottis folds over during swallowing and saw no evidence of any contraction of the posterior pharyngeal wall. These deviations were refuted, first by Johnstone (10), who proved his points with exceptionally good x-ray films, and then by Rushmer and Hendron (11), and by Saunders, Davis, and Miller (12), with the help of cinefluorographic studies.

Barclay's work on swallowing re-awakened interest in a rather neglected subject. It also emphasized the fact that fluoroscopy as a research method is particularly vulnerable to the inroads of the subjective element, represented in Barclay's case by a profound mistrust of accepted teaching. The trouble with fluoroscopy arises partly from shortcomings of the apparatus and partly from the inability of the human eye to analyze rapid, complex motion. This limitation, by the way, is fully recognized and allowed for in the x-ray examination of the pharynx, a routine diagnostic procedure which grew up side by side with the work on swallowing, but took a more practical turn. Thus we find Templeton (13) advising the fluoroscopist to concentrate on certain easily repeatable views of the pharynx, all but two of which are static. Even the two views of the pharynx at the height of swallowing are treated as "stills," attention being focused on the bulges and indentations of the barium column within the distended lumen. And finally, spot films are taken as an added hedge against the subjective element.

In order to attain a similar objectivity in x-ray studies of the complexities of second stage swallowing, investigators soon realized that it would be necessary to make the equivalent of a great many spot films in a very short time; in other words, to resort to slow motion cinematography. This finally became possible with the development of Janker's 35-mm. cinefluorographic

apparatus about 1936 (14). Since then, slow, or fairly slow, motion studies of swallowing have been made by Janker himself, and by a number of other investigators. Of special interest are the papers which have appeared since the war, by Rushmer and Hendron, by Ardran and Kemp (15 and 16), who examined 500 normal young adults, and by Saunders, Davis, and Miller, whose paper includes an admirable review of the subject up to 1949. The use of cinefluorography has already contributed much interesting new information about the swallowing mechanism, and we have tried, in going over the same ground, to give credit to the original observer wherever possible. Needless to say, the new motion technic can hardly be expected to eliminate disagreement, but at least the disagreement should be less about what is observed than about how it is interpreted.

#### MATERIAL AND METHOD

The present paper is based upon cinefluorographic studies of some 300 individuals, about half of whom were considered to be normals. They were of both sexes, varying in age from a few weeks to eighty years. They were examined in various positions, erect, prone, supine, and Trendelenburg, and in both anterior and lateral projections. Oblique projections were occasionally employed. For normal adults the contrast medium was a mixture of barium sulfate and water. Incidentally, the term "bolus" has been used throughout to indicate that portion of the material taken into the mouth which is separated by the tongue to form a single swallow.

Examinations were recorded on 35-mm. film at camera speeds of 30 and 60 frames per second. Apparatus and technical factors have been described elsewhere (17). Each scene of swallowing was studied as a continuous loop on the projector, and by single framing, tracings, and paper enlargements of the more difficult phases of the action.

From this mass of material we have attempted to pick out and verify the most

usual sequence of events observable in the swallowing of semi-liquid barium suspensions, and to describe the variations which result from changes in the position of the subject and in the size and consistency of the bolus. We have also described a quite different technic used by persons who have trained themselves to drink, as Magendie says, "*à la régaleade*," that is, by pouring beverages into their wide open mouths.

We do not believe that this account of the cineradiographic appearances of normal swallowing is in any sense complete, but rather feel that additional understanding of the many details can be gained by further study of normal subjects and animals, and by analysis of various pathologic conditions that occur in the area. Much also remains to be done on the purely technical side of cineradiography, and not alone from the point of view of image sharpness. Everyone who has worked in this field has remarked on the increase of information that results from doubling the speed of the camera, and there is reason to think that a further speed-up, from 60 to 120 frames per second, will produce a similar gain.

It will be noticed that the various moves and countermoves of the structures involved in swallowing have been divided as far as possible into two classes: those which tend to expand the food channel to make room for the bolus and those which narrow and obliterate the food channel behind it. This dual concept of function originated with Bayliss and Starling some fifty years ago. While later experiments have failed to confirm the "law of the intestine" as it was originally formulated (18), the general idea continues to show much vitality as a working hypothesis in explaining how food is transported through certain parts of the digestive tract.

For purposes of description, the passage of the bolus will be dealt with in three sections: its entrance into the oral pharynx, its transmission through the laryngeal pharynx, and finally its passage through the hypopharynx (the cricoid portion of

the laryngeal pharynx) and into the esophagus. Such a division can be defended on anatomical and functional grounds but should not be allowed to obscure the essential continuity and interdependence of the events which go to make up the act of swallowing.

#### I. PASSAGE OF THE BOLUS INTO THE ORAL PHARYNX

The initiation of bolus transport involves the tongue, the soft palate, the muscular wall of the pharynx, and the faucial pillars. These active structures function in two ways. First, by expanding the lumen, they make room for the passage of the bolus. Then, by progressively narrowing and closing the lumen behind the bolus, they propel it into and through the oral pharynx. Expansion of the lumen is accomplished primarily by elevation of the soft palate, relaxation of the faucial pillars, and depression and grooving of the posterior tongue. Closure of the lumen behind the bolus is accomplished by pressure of the dorsum of the tongue, first against the hard palate, and then against the soft palate, which is now brought downward in opposition to the dorsum of the tongue by the contraction of the posterior faucial pillars and then forward against the root of the tongue by contraction of the superior and middle constrictors of the pharynx (10).

*The Function of the Tongue:* Swallowing begins with a somewhat complicated but characteristic gesture of the tongue. In the preliminary stage, after material has been taken into the mouth, the tip of the tongue segregates the bolus from material to be swallowed later, the mid-section of the tongue is depressed and grooved centrally to accommodate the bolus, and the base of the tongue is displaced a little backward, narrowing the lumen of the oral pharynx. This tentative "backward thrust of the tongue" (12) is only temporary. Once the decision to swallow has been made, the forepart of the tongue is pressed firmly against the roof of the mouth, while the posterior part forms a

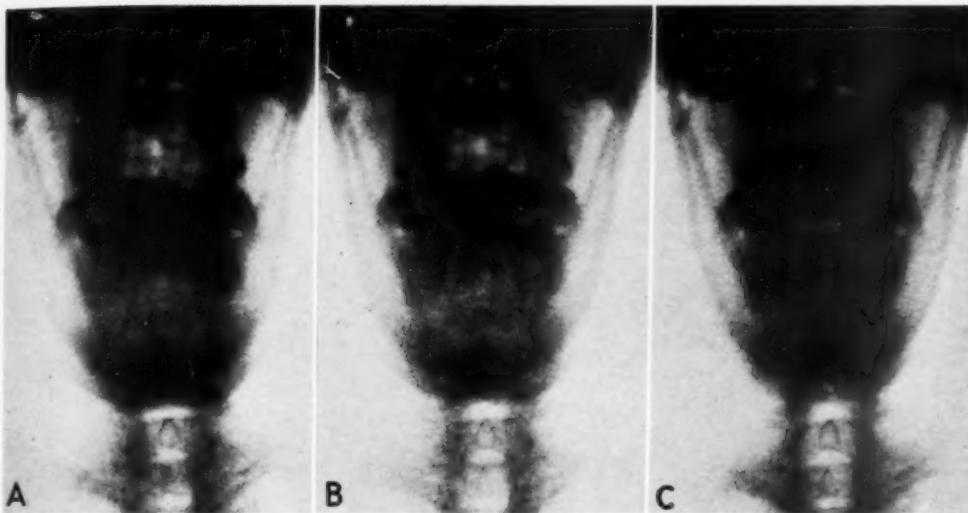


Fig. 1. Passage of the bolus into the oral pharynx. Anterior view, looking obliquely downward and backward. Male, age 57. Liquid barium mixture.

- A. The bolus lies on the grooved dorsum of the tongue, preparatory to swallowing.
- B. As the bolus moves toward the fauces, the groove deepens.
- C. The bolus is now passing through the fauces. The apparent elevation of the bolus as compared with A and B is due to the oblique projection.

grooved chute down which the bolus passes into the oral pharynx (Fig. 4C).

Grooving of the tongue is best seen in the anterior view (Fig. 1). The groove is shallow at first, and the bolus, since it extends laterally to the tongue margins, has a double-winged appearance. As the bolus moves toward the fauces, the groove deepens; the lower border of the bolus becomes rounded, the lateral "wings" disappear, and the bolus, assuming a round or oval cross section, is funneled through the fauces (Fig. 1C).

In the lateral view, grooving of the tongue is occasionally indicated by the appearance of a triple contrast outline of the dorsum. Also seen in most swallows is a rapid forward movement of the entire dorsally directed surface of the posterior tongue, which occurs while the bolus is approaching the valleculae and reverses the preliminary "backward thrust" (Fig. 4, B and C). The movement of the tongue away from the posterior pharyngeal wall obviously results in an increase of the anteroposterior dimension of the oral pharynx ahead of the bolus, but whether

this is truly active expansion of the lumen or merely compensates for a simultaneous narrowing from side to side is hard to say.

Meanwhile the propulsive action of the forepart of the tongue is already being applied to the tail of the bolus. As more and more of the dorsum of the tongue adheres to the roof of the mouth, the tail of the bolus is crowded or "stripped" in the direction of the oral pharynx (Fig. 3, C and D). This progressive narrowing and obliteration of the lumen behind the bolus will hereafter be called the "stripping action" or "stripping wave." If the bolus is large and relatively hard to compress, or sticky, the stripping wave has real work to do and appears correspondingly forceful. On the other hand, if the bolus is small and fluid, its passage is so easy that the stripping wave appears to do little more than wipe the surfaces of residue.

The final participation of the tongue in the stripping wave occurs when the base of the tongue is opposed by the soft palate and muscular walls of the oral pharynx. The question raised by previous investigators as to whether the tongue or the pos-

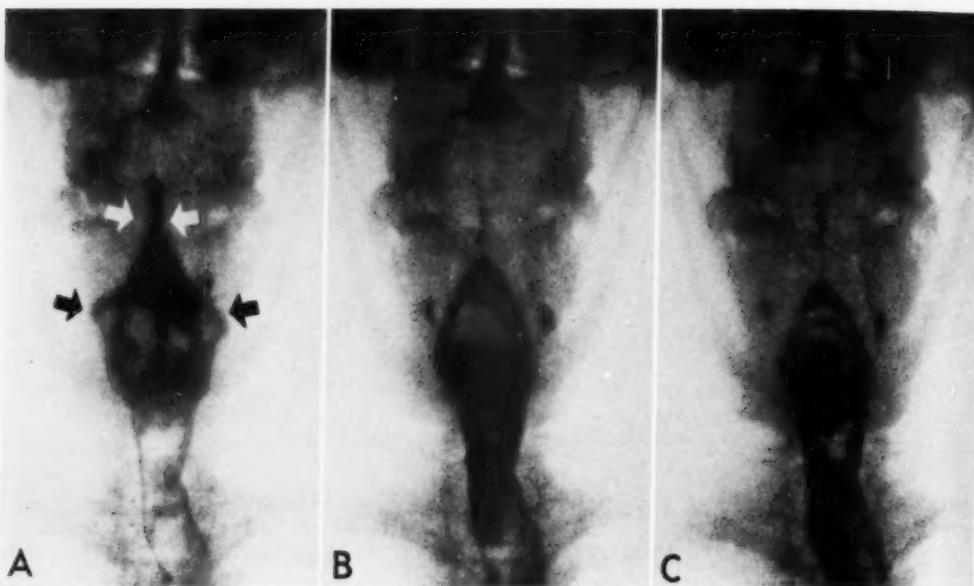


Fig. 2. Continuation of Fig. 1. The stripping wave of the oral pharynx seen from the front.

A. The lateral walls of the oral pharynx and the posterior faucial pillars, indicated by white arrows, are contracting on the tail of the bolus. The laryngeal pharynx is moderately distended, and a stream of fluid has passed centrally over the epiglottis and laryngeal entrance. The black arrows point to bulges of the pharyngeal lumen at the upper margins of the thyroid laminae.

B. The stripping wave has reached the valleculae. Liquid flows on either side of the aryepiglottic folds in the foreshortened pyriform sinuses.

C. The pharyngeal lumen has been obliterated down to the base of the epiglottis. The latter is inverted, and a little fluid can be seen beneath its undersurface. Note that the dorsum of the tongue is still pressed firmly against the roof of the mouth.

terior pharyngeal wall is the major propelling force in this part of the lumen would seem to be irrelevant, since the two actions are plainly complementary.

*Role of the Soft Palate and Posterior Faucial Pillars:* Elevation of the soft palate is nearly always completed before the head of the bolus has reached the valleculae. The movement is accompanied by a shortening and thickening of the entire structure and a humping of its dorsal surface into the nasopharynx and against the posterior pharyngeal wall, the relaxed posterior faucial pillars being swung in the same direction (Figs. 3 and 4). Elevation of the soft palate helps to expand the lumen ahead of the bolus, while its contact with the posterior pharyngeal wall effectually blocks off the nasopharynx and nasal cavities.

During the passage of the last of the swallowed material through the fauces, the

soft palate is pulled down again from its elevated position by contraction of the pharyngopalatinus muscles situated in the posterior faucial pillars (1). The under surface of the soft palate is thus brought in contact with the dorsum of the tongue and takes part in the stripping wave. Near the end of the swallow the soft palate has been pulled down so far that the uvula can be seen at vallecular level (Fig. 5C).

Although the bulk of the food mass usually passes in front of the posterior faucial pillars, some of the material may find its way between them and upward into the space behind the lower portion of the soft palate. At such times the pillars can be seen as streaks of decreased density through the bolus, and at others as coated parallel ridges along the posterolateral walls of the oropharynx (Fig. 4B).

The anteroposterior projection shows the

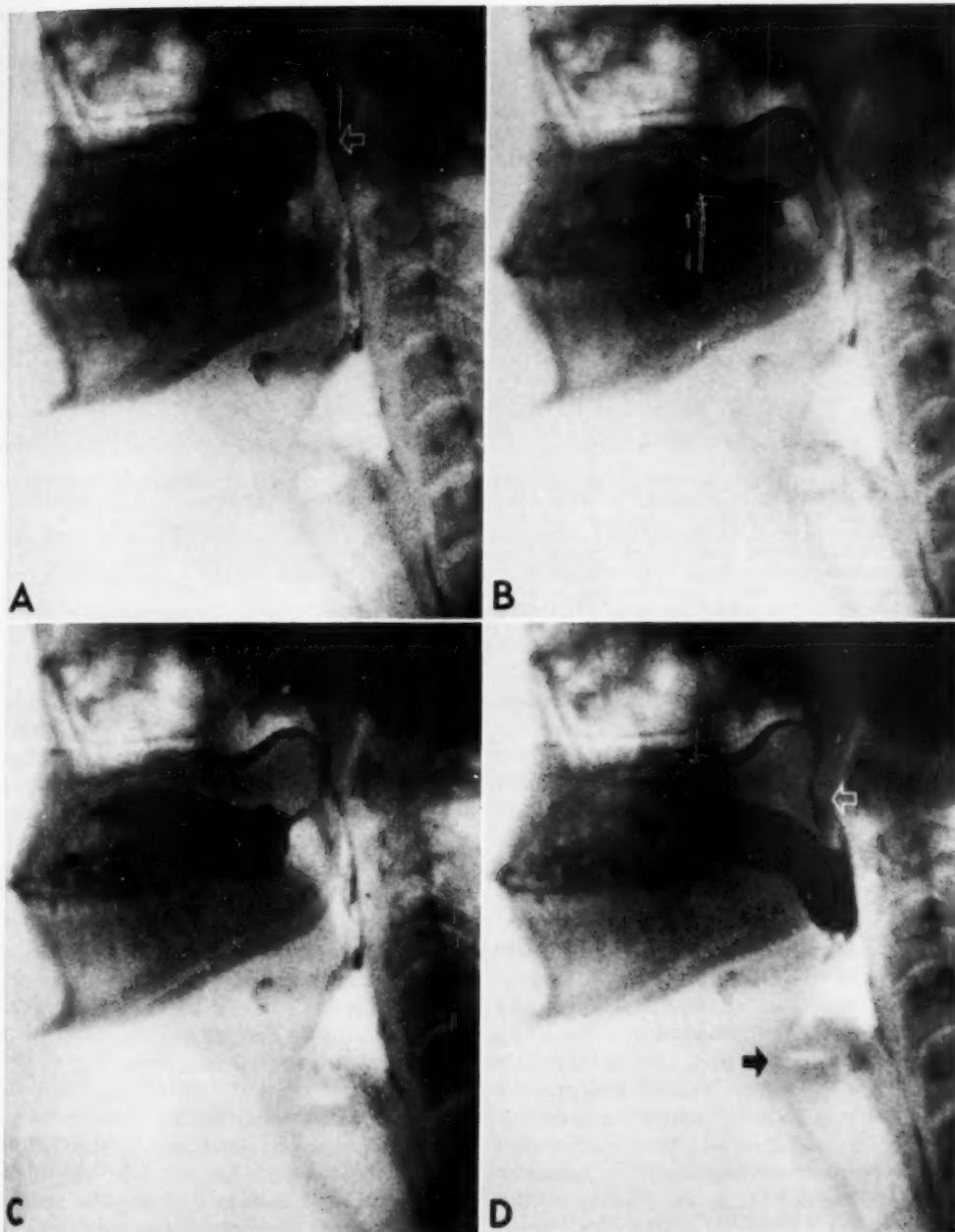


Fig. 3. Closure of the nasal pharynx. Lateral view. Female, age 19. Semi-liquid barium mixture. The upper and posterior surfaces of the soft palate have been coated with thick barium paste.

A. The bolus is being moved backward by the tongue. The soft palate is partly elevated. Arrow points to bulge of posterior pharyngeal wall at Passavant's ridge.

B. 1/60 second later. The soft palate continues to approach the posterior wall.

C. 1/60 second later. The soft palate makes contact with Passavant's ridge.

D. 4/60 second later. The nasal pharynx is now completely sealed off. The local contraction of the posterior wall (white arrow) has deepened and will begin to move downward as soon as the tail of the bolus enters the oral pharynx. Note that the hyoid bone and larynx are rising, the laryngeal airway narrowing. The black arrow points to the narrowed laryngeal ventricle.

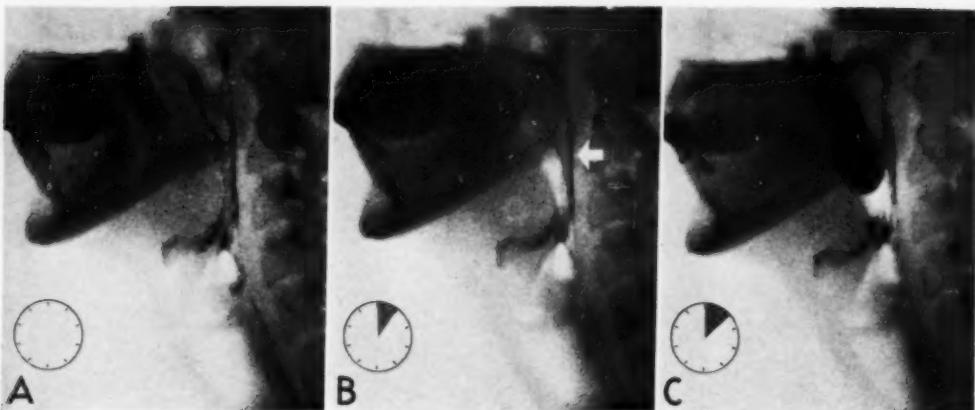


Fig. 4. Entrance of the bolus into the oral pharynx, lateral view. Female, age 20. Semi-liquid barium mixture. Elapsed time is indicated on dial marked in tenths of a second. Nasal pharynx has been coated with barium paste as in Fig. 3.

A. The soft palate is relaxed and rests on the base of the tongue behind the bolus. The lumen of the oral pharynx is narrowed by a slight backward thrust of the base of the tongue.

B. The soft palate is rising. The head of the bolus has reached the anterior faucial pillars. The relaxed posterior pillars lie against the posterior wall (white arrow).

C. The soft palate is fully elevated. The bolus is approaching the valleculae. The forepart of the tongue is being pressed against the hard palate, while the base of the tongue is moving forward to make room for the bolus. Note that the hyoid bone is beginning to move upward and forward, the epiglottis upward.

stripping wave from a different angle. During the preliminary expansion of the lumen, while the soft palate is still at the height of its elevation, the posterior faucial pillars cannot be seen from the front, but they are known (from observations made in the oblique view) to be partly relaxed and separated. Their subsequent contraction behind the bolus not only depresses the soft palate but tends to bring the lateral soft tissues together in the midline, an effect which is apparently reinforced by the contraction of the upper group of constrictors. Whatever the means, the lateral walls of the oral pharynx can clearly be seen to approach each other, narrowing and progressively obliterating the lumen from above downward, and perhaps playing a part in the folding over of the epiglottis (Fig. 2). Once the lumen has been closed by the stripping wave, it stays closed; the overall muscular contraction is maintained until the end of the pharyngeal stage of swallowing.

*Role of the Superior and Middle Constrictors:* Coincident with the elevation of the soft palate and usually a little prior to any movement of the hyoid bone or

larynx, there begins an upward excursion of the posterior pharyngeal wall which eventually equals about the width of a vertebral body. This is the earliest of the observations which support the often repeated statement that the pharynx is "drawn up around the bolus." At the same time, a fairly deep indentation of the posterior wall appears in the region of Passavant's ridge and bulges against the dorsal surface of the rising soft palate, ultimately reinforcing the closure of the nasal pharynx (Fig. 3). The indentation has been interpreted as a wrinkling of the wall of the pharynx caused by the contraction of its longitudinal muscle fibers, but it seems likely that the contraction of the circular fibers has already begun at this level and is a more decisive factor. With the first downward move of the soft palate, the indentation also moves downward to take part in the stripping wave of the oral pharynx. Unless a special contrast technic has been used, however, the soft palate and the thickened pharyngeal wall behind it will appear in the lateral view as an undifferentiated mass above the tail of the bolus. To separate the struc-

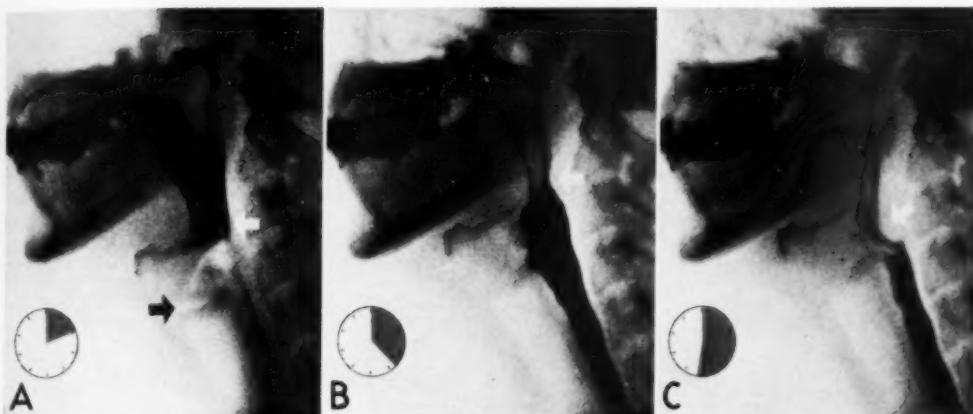


Fig. 5. Continuation of Fig. 4. The bolus is propelled through the pharynx.

A. The head of the bolus lies on the epiglottis, indicated by the white arrow. The black arrow points to the still open laryngeal ventricle, through which air, displaced from the pharynx, is passing into the trachea.

B. Barium now distends the laryngeal pharynx, hypopharynx, and upper esophagus. The larynx is elevated and the airway obliterated. The soft palate has been pulled down by the contraction of the posterior pillars. The arrow points to the contraction wave of the posterior wall, which has moved downward almost to vallecular level.

C. The tail of the bolus is being squeezed from the valleculae (arrow). Note thickening of the posterior wall above this point as compared with A. The lumen of the oral pharynx has been completely obliterated by the stripping wave.

tures the upper and dorsal surfaces of the soft palate should first be coated with a fairly thick barium paste (Figs. 3 and 4).

It is interesting to note that the early traveling indentation of the posterior wall of the oral pharynx can only occasionally be followed downward through the pharynx and into the esophagus. More frequently the wave seems to disappear opposite the base of the tongue, and an apparently new wave starts lower down. We shall return to this subject in discussing the pharyngeal stripping wave in Section II (p. 511).

## II. PASSAGE OF THE BOLUS THROUGH THE LARYNGEAL PHARYNX

Passage of the bolus through the laryngeal pharynx involves observable movements of the hyoid bone, the epiglottis, the larynx, and the pharyngeal walls. The most striking and familiar event of this stage of swallowing is the vigorous upward movement of larynx and trachea and of laryngeal pharynx, hypopharynx, and upper esophagus. The upward climb of these structures is led off, so to speak, by an upward and forward (or forward and upward) movement of the hyoid bone. Un-

less the bolus is very small, the larynx too moves forward (as well as upward), and with it moves the attached anterior wall of the pharynx. The extent of forward travel appears to be related directly to bolus size (15). The larynx moves forward out of the way, permitting an increase in the anteroposterior diameter of the pharyngeal lumen (Fig. 5). The general upward travel, on the other hand, serves to shorten the lumen longitudinally and also plays a part in the important displacements which protect the laryngeal air passage.

*Movements of the Hyoid Bone:* Hyoid movement begins during the preliminary upward climb of the posterior pharyngeal wall and before the bolus has reached the valleculae (Fig. 4C). The movement is of two general types. With a large bolus the entire hyoid bone moves obliquely forward and upward, the forward component being the larger. With a small bolus, the movement is first upward and then a little forward. The regularity of these responses gives the impression that the motor centers are receiving precise "information" as to bolus size.

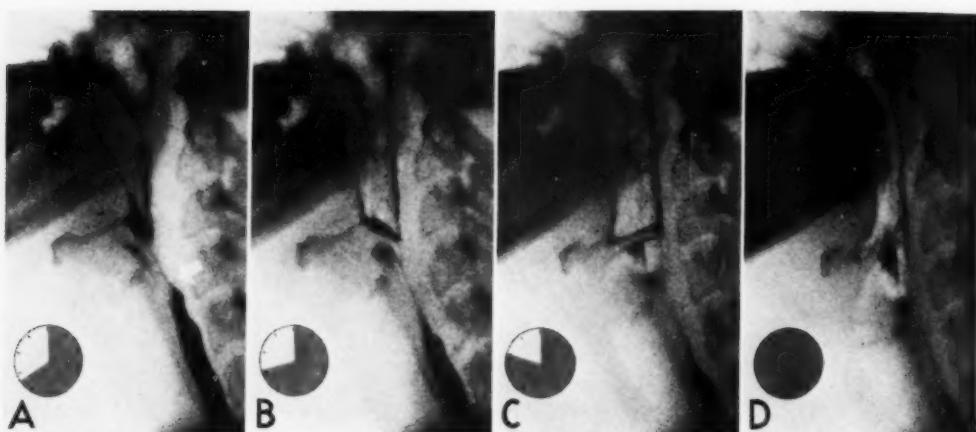


Fig. 6. Continuation of Fig. 5. The return of the pharynx to the resting stage.  
 A. Arrow points to the stripping wave, which is now emptying the hypopharynx. The soft palate is beginning to fall away from the posterior wall, thus permitting the nasal pharynx to open.  
 B. The tongue and posterior wall are separating, allowing the pharyngeal lumen to fill with air from above. The epiglottis is ready to spring back into resting position.  
 C. The hyoid bone and the larynx are dropping downward. The laryngeal airway is beginning to open for breathing.  
 D. The resting stage of the pharynx has been re-established. Note the tail of the bolus disappearing down the esophagus.

*Behavior of the Epiglottis:* We have seen how the base of the tongue moves away from the posterior pharyngeal wall as the bolus descends toward the valleculae. At the same time, the beginning upward excursion of the larynx thrusts the epiglottis in the direction of the oncoming bolus (Fig. 4C). As the two meet, the tip of the epiglottis tilts dorsally into contact with the posterior pharyngeal wall (Fig. 5A) and seems momentarily to obstruct the lumen (Ardran's stage of vallecular arrest). By this time, the gaping valleculae are filled with material, which, if at all fluid, immediately begins to spill laterally into the pyriform sinuses on either side of the aryepiglottic folds (Fig. 8, B and C). Meanwhile, apparently in response to the further upward and forward movement of the larynx, the epiglottis continues to fold backward until it passes the horizontal and dumps any remaining vallecular contents over its tip into the laryngeal pharynx (Fig. 5B). So long as the pharynx remains distended with barium, the epiglottis hangs slantwise in the stream. With the arrival of the stripping wave the epiglottis is squeezed more closely against

the posterior surface of the larynx, and its tip is carried downward nearly to the cricoid lamina (Fig. 6A).

The folding over of the epiglottis opens up the valleculae and tends to streamline the lumen, and to this extent it can be said to contribute to lumen expansion. It also serves to shield the entrance of the larynx, though there is little evidence of the "lid-like" action described in some of the older physiology books. The epiglottis does not fit the laryngeal entrance tightly enough to keep out liquids, but it does prevent semi-liquid and solid material from coming in direct contact with the entrance, and also sweeps residual material from this part of the pharyngeal lumen when it springs upward again at the end of the swallow (Fig. 11C).

That the folding over of the epiglottis can be safely delayed until long after its customary time is shown in our studies of a trained beer drinker, who downs nearly a whole glass of liquid with the epiglottis in upright position (Fig. 12).

As to what folds the epiglottis over, cinefluorography does not offer much in the way of direct information. The shorten-

ing of the aryepiglottic folds during second stage swallowing (well illustrated by Saunders, Davis, and Miller) is presumably accompanied by a contraction of the aryepiglottic muscles, and this may play a part in depressing the epiglottis, as was surmised by Haller. But it seems that these muscles are hardly strong enough to do the work unaided.

Another early explanation is implied in the following passage from Magendie: "At the same time that the os-hyoïdes and the larynx elevate themselves, they approach each other; that is, the superior edge of the thyroid cartilage is pressed behind the body of the os-hyoïdes, the gland (fat pad) of the epiglottis is pushed backward, and the epiglottis itself is depressed and inclines backward and downward. . ."

What Magendie says about the fat pad cannot very well be checked by cinefluorography alone; nor, for that matter, can the hypothetical actions of the various muscles, membranes, and ligaments implicated in the mechanism by more recent theorists. Testing these theories would require some pretty elaborate surgical experiments. At present, about all that can

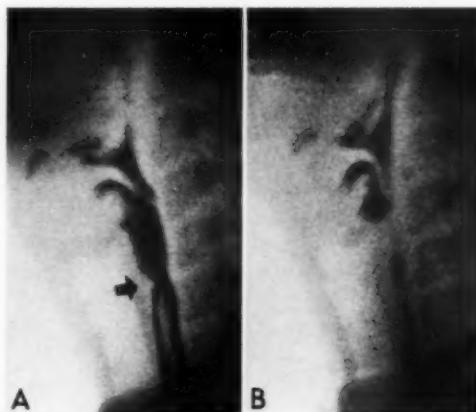


Fig. 7. Attitudes of the inverted epiglottis in repetitive swallowing. Lateral view. Male, age 26. Liquid bolus.

A. The epiglottis hangs diagonally in the barium stream with its tip against the posterior wall. Arrow points to a typical indentation of the anterior wall of the hypopharynx which occurs regularly in some subjects but not in others. Templeton explains it as being due to a high point on the cricoid lamina. The fact that it cannot be seen in B is unusual and puzzling.

B. With the emptying of the laryngeal pharynx, the epiglottis is squeezed more closely against the back of the larynx, though not so closely as during the final stripping wave. Note that the barium beneath the epiglottis has penetrated a little farther into the vestibule than in A. The hyoid and larynx have dropped down a little, but the glottis remains closed between swallows.

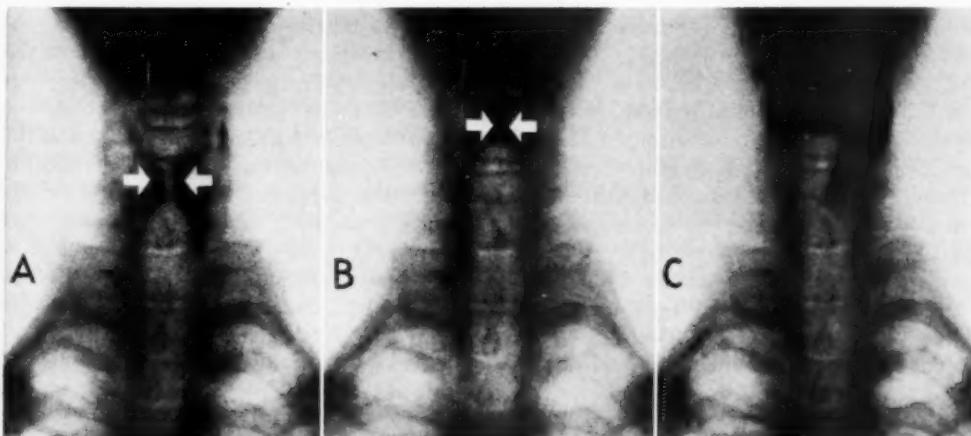


Fig. 8. Elevation and closure of the larynx. Anterior view. Male, age 53. Semi-liquid barium mixture. A. The larynx and pharynx are in resting position. The ventricular and vocal folds are still open for breathing. The partly collapsed laryngeal ventricle is indicated by the arrows.

B. The bolus has reached the valleculae, and is just beginning to spill over the left margin of the epiglottis. The larynx has moved upward one and one half vertebral bodies. Arrows point to the level of the laryngeal ventricle, which is now tightly closed.

C. The barium mixture is flowing round each side of the epiglottis and aryepiglottic folds in the pyriform sinuses. Lack of symmetry is probably an age change. Note that the larynx has moved a little farther upward than in B.

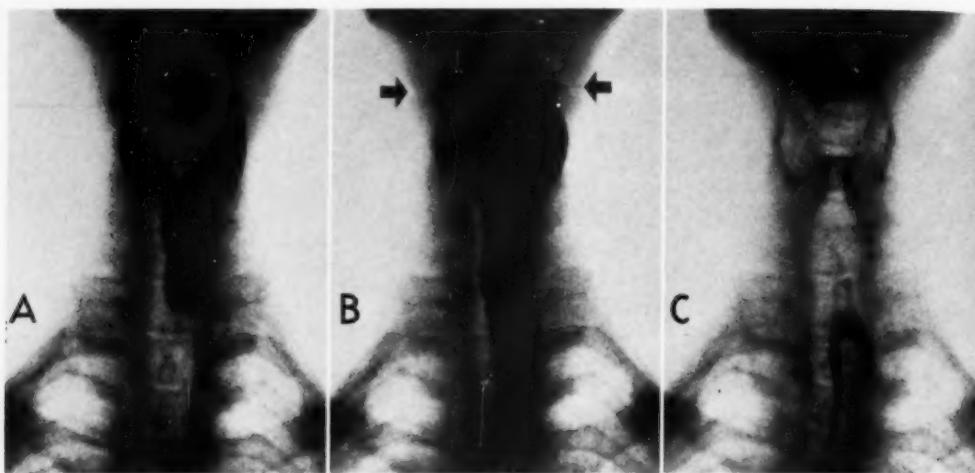


Fig. 9. Continuation of Fig. 8. Passage of the bolus through the pharynx.

A. The pyriform sinuses and hypopharynx are now filled with barium. The upper border of the central, low-density area is formed by the epiglottis, which is turning downward over the laryngeal vestibule.

B. The oral pharynx, above the arrows, is being compressed from side to side by the stripping wave, producing maximal distention of the laryngeal pharynx. The epiglottis is now hidden by barium which fills the posterior pharynx. Arrows point to the out-pouching of the lateral walls of the pharynx between the upper margins of the thyroid laminae and the hyoid.

C. The swallow is over, and the larynx and pharynx have returned to resting position. The glottis is again open for breathing. The pyriform sinuses and aryepiglottic folds are outlined by residual barium and air. Slight deviation of the upper esophagus to the left is a normal finding.

be agreed on is that the folding over of the epiglottis is contingent on the elevation of the larynx and does not take place except when the larynx is moving upward and the bolus and stripping wave are moving downward.

*Closure of the Laryngeal Airway:* Once started, the larynx climbs faster than the hyoid and, in the lateral view, appears to be "telescoping" itself against the root of the tongue. This impression is strengthened by the folding over of the epiglottis on the rest of the larynx and by the consequent bending backward and narrowing of the laryngeal air column (Fig. 5A). The communicating air column of the laryngeal pharynx is meanwhile also being compressed by the approaching bolus, and the air thus displaced escapes through the still open glottis into the trachea (10). If the bolus is sufficiently fluid, some of it regularly finds its way under the epiglottis and into the laryngeal vestibule (Fig. 7), on the heels, so to speak, of the aspirated air (14). The invasion is generally halted by reflex closure of the ventricular folds,

but on rare occasions a little fluid may get past them into the ventricle, where it is finally checked by closure of the glottis (Fig. 12B). In any case, all of the invading fluid is eventually squeezed out again into the pharynx at the time of the stripping wave, apparently by the contraction of the vestibular sphincters.

The most important, single factor in the protection of the airway, at least during the actual swallow, is the closure of the glottis, marked in the lateral view by the disappearance of the ventricular air shadow (Fig. 5), and directly visible in the anterior view, when not hidden by the bolus (Fig. 8). As a rule, the glottis closes sooner when fluids are being swallowed than it does for semi-liquids or pastes, probably because the latter do not invade the vestibule. The subsequent squeezing out of fluid from the vestibule at the time of the stripping wave suggests that the laryngeal sphincters are undergoing a sort of stripping wave of their own from below upward (14), the purpose being to make sure that no foreign matter shall be left

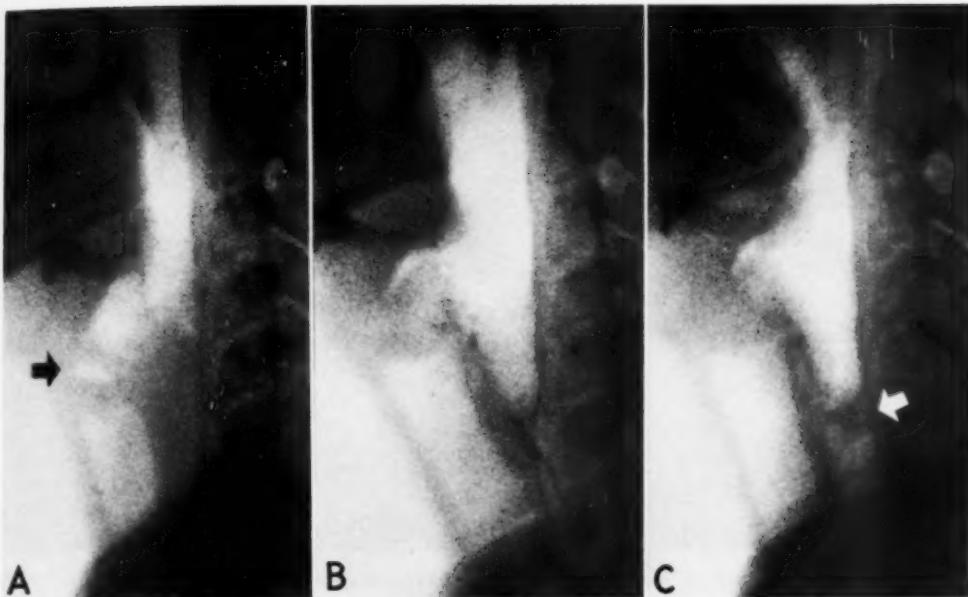


Fig. 10. Movements of the larynx during voluntary belching. Lateral view. Female, age 21.

- A. The larynx is partly elevated and is beginning to move forward. Arrow points to the laryngeal ventricle which still contains air, indicating that the glottis is open.
- B. The larynx is now fully elevated and pulled forward, the upper part leaning far away from the spine. The glottis is closed. Note column of air in the upper esophagus, waiting to get by the cricopharyngeus muscle.
- C. 1/10 second later. The upper part of the larynx has moved back a little, but the cricoid portion has been pulled farther forward. Air from the esophagus is escaping through a narrow slit between the anterior wall of the hypopharynx and the partly relaxed cricopharyngeus muscle (arrow). Intermittent escape of air causes the sound of the belch.

in the airway when the subject begins to breathe.

The sphincter muscles, of course, cannot be seen directly on the film, and even the calcified arytenoids are generally not well enough outlined to give more than a vague hint of what they are doing. The one clear sign of arytenoid activity is the triangular bulge, sometimes quite deep, of the anterior margin of the barium column just above the vocal folds (Fig. 5B). The bulge occurs when the arytenoids rotate forward on the cricoarytenoid articulation at the time of the closure of the glottis.

Ardran suggests that the glottis, even when it appears to be closed, may still not be airtight, since "it has frequently been observed that a column of air is drawn into the pharynx and swallowed with the bolus." If air does indeed enter the pharynx through the glottis at this stage, it would mean either that negative pressure

is produced momentarily in the pharynx and upper esophagus (as Barclay maintained), or else that intrathoracic pressure is suddenly increased during the passage of the bolus past the larynx. We have not so far succeeded in repeating the observation, although we have seen air that was trapped in the vestibule by the closure of the glottis later squeezed out again into the pharynx and swallowed.

*Lumen Expansion in the Pharynx:* In going from the oral to the laryngeal pharynx, the posterior wall of the lumen stays pliable, but the anterior wall, now formed by the back of the larynx, is inflexible except at the cricothyroid articulation. This naturally affects the way in which the lumen expands. With the arrival of the leading portion of the bolus in the valleculae, the larynx, which is already rising, begins to move forward. The upper part of the laryngeal assembly

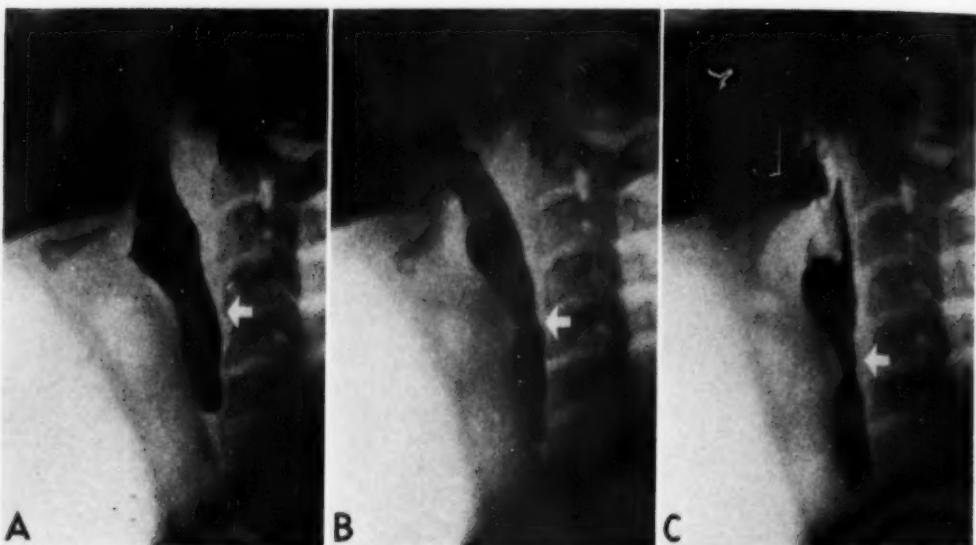


Fig. 11. Reflex relationship between the glottis and the cricopharyngeus muscle. Female, age 19. Thick barium paste.

A. Thick barium paste distends the pharynx and upper esophagus. The stripping wave has succeeded in narrowing the oral pharynx but is not powerful enough to obliterate the lumen. The laryngeal airway closed. Arrow points to the cricopharyngeus muscle which is fully relaxed.

B. 1/2 second later. A second stripping wave (repetitive swallowing technic) has failed to clear the lumen of barium. Nothing remains but to relax, gather saliva, and try again. The larynx has begun to drop down, and the cricopharyngeus muscle shows reflex contraction. Note the emergency tilting of the hyoid bone.

C. 1/2 second later. The laryngeal airway and pharynx are now wide open and filled with air. The cricopharyngeus muscle has contracted the hypopharynx at the point shown by the arrow. Residual barium paste has been swept upward, away from the laryngeal entrance by the upturning epiglottis. The hyoid bone has returned to its elevated position in preparation for the next swallow, now just beginning. Hyoid behavior here is an emergency phenomenon.

leans away from the spine first and is followed later by the lower part, as the bolus moves downward to distend the hypopharynx. If the bolus is of any size, the larynx seems to rock forward over it and then back, as though displaced by the moving food mass (Fig. 5). However, there is good reason to think that the attitude and position of the larynx are constantly under the control of the anterior neck muscles, which are known to be perfectly capable, by themselves, of pulling the larynx forward as well as upward, and backward as well as downward (Fig. 10).

While the anterior wall of the lumen is moving forward, the muscular wall behind it is relaxing around the bolus, presumably in response to reflex inhibitory stimuli. Not much expansion is needed for a small bolus; but a large bolus fills out the lumen and distends the pyriform sinuses to the

limit, even spreading apart the laminae of the thyroid cartilage (Fig. 9). The full extent to which the pharynx can be dilated is well shown in Templeton's modification of the Valsalva maneuver, though here, of course, the larynx and pharynx are in resting position. Not only are the thyroid laminae spread widely apart; there is also a bulging of the lateral walls of the pharynx between the upper margin of the laminae and the hyoid. The bulging is also often seen during swallowing, especially in older subjects. Whether these bilateral pouches deserve to be called diverticula seems doubtful, except in extreme cases. They are easiest to see in the anterior view (Fig. 2) but can sometimes be made out in the lateral, where they complicate the pharyngeal silhouette by appearing first above the valleculae during the stripping wave, and then behind the epiglottis after

its return to resting position. An unusual one-sided pouch of this sort can be seen in Figure 5C anterior to the uvula, and in Figure 6 in the neighborhood of the epiglottis. The subject had no symptoms of dysphagia.

Another observation of Templeton's on second-stage filling has to do with the pyriform sinuses and is amply confirmed by cinefluorography. If the subject's head is turned to one side during swallowing, the bolus tends to pass down the opposite pyriform sinus. This perfectly normal finding is sometimes mistaken on spot films for evidence of a pharyngeal lesion.

*The Pharyngeal Stripping Wave:* As already mentioned, the contraction wave of the posterior wall of the oral pharynx generally appears to fade out, and a new wave to begin opposite the vallecular recess. However, from a functional point of view there is little doubt that the lower wave is the continuation of the upper wave. The apparent break in continuity results from the fact that the early indentation of the posterior wall behind the soft palate appears deepest while it is waiting for the tail of the bolus to pass the fauces (Fig. 3D). As soon as the wave begins to move downward, it is flattened against the convex dorsal surface of the soft palate, now molded by the base of the tongue, which is moving backward to take part in the stripping action. Our sequence of lateral views in Figure 5 skips over the actual passage of the stripping wave through the oral pharynx, but proof that it has really passed can be seen in the increased thickness of the posterior wall in Figure 5C. Below the root of the tongue, the anterior wall of the lumen no longer takes much part in the stripping wave. The posterior wall must do the work alone, and hence develops a more conspicuous indentation (Figs. 5C and 6).

The shape of the traveling indentation of the posterior wall is always step-like, with the riser of the step facing the vertebral column. This is because the lumen does not fill out again behind the wave, but remains contracted, as though to

guard against the possibility of reflux. The extent to which the wave indents the posterior wall of the laryngeal pharynx depends partly on individual variations and partly on bolus volume and consistency. A large, relatively incompressible bolus occupies more room and is followed by a deeper indentation than a small, elongated bolus. Whether the force of the contraction also varies under such conditions would have to be determined by methods other than cinefluorography. A glance at Figure 11 will show that the force of the contraction is by no means irresistible.

In the anterior view, it can be seen that the stripping wave is able to bring the lateral walls of the lumen together only as far down as the base of the epiglottis. Below this level the pharyngeal mucosa is attached to the inner sides of the thyroid laminae. Since the fibers of the inferior constrictor arise from the outer sides of the cartilage, their contraction would be expected to have no more effect on the lateral diameter of the lumen than it has on the separation of the laminae. Actually, the contraction does appear to narrow the lumen a little from side to side, though it never succeeds, of course, in bringing the walls together in the midline. In Figure 2 the lateral pouches, which are anchored to the upper margins of the thyroid laminae, are isolated and left behind by the stripping wave.

The authors believe that the stripping wave, which begins in the mouth and passes through the different levels of the pharynx and upper esophagus, is the major propulsive force in all normal swallowing of semi-liquid and solid material. Liquids are often helped on their way through certain parts of the lumen by gravity. Nevertheless, until the esophagus is reached, the stripping wave always follows closely on the tail of the bolus, however far in advance the leading portion may have traveled.

### III. PASSAGE OF THE BOLUS THROUGH THE HYPOPHARYNX

The cricoid portion of the laryngeal

pharynx, here termed the hypopharynx, lies well below the laryngeal vestibule and therefore has a comparatively simple cross section, the lateral dimension being the wider. The anterior wall is attached to the back of the cricoid lamina, while the lateral and posterior walls are supported by those fibers of the inferior constrictor which arise from the cricoid's lateral surfaces. This lowest part of the inferior constrictor, now generally known as the cricopharyngeus muscle, was the subject of a special study by Killian (19) in 1908. According to Negus (20, 21), its principal function is to guard the upper end of the esophagus against the entrance of air during respiration. It is said to be in a state of tonic contraction at all times except during belching, vomiting, and swallowing.

Lateral views of the region show one detail which does not fit very well with the anatomical description, namely, the behavior of the anterior wall. While the lumen is distended with barium, as in Figure 5B, the anterior wall appears to be lying as flat against the back of the cricoid as the uneven surface of the cartilage will permit. When the hypopharynx contracts, however, the supposedly non-muscular anterior wall thickens considerably, so that the lumen retreats from the cricoid and comes to lie halfway between the back of the cricoid and the front of the vertebral column (Fig. 6). About the only way to explain this is to assume that the anterior mucosa is somehow wrinkled into space-occupying folds whenever the cricopharyngeus muscle contracts.

The cricopharyngeus generally relaxes and opens as soon as the head of the bolus reaches it; but in the case of fluids there may be a slight delay, the meaning of which is discussed in the paragraphs on gravity in Section IV (p. 513). That the muscle does not always relax completely in normal swallowing is shown by an occasional transitory notching of the posterior wall of the hypopharynx (13) during the passage of the bolus.

A most significant reflex relationship undoubtedly exists between the cricopharyn-

geus and the constrictor mechanism of the glottis (Fig. 11). In our films of belching and swallowing we have never seen the hypopharynx and the glottis open at the same time. This tends to support Negus' view of the function of the cricopharyngeus.

*The End of the Swallowing Act:* "The act of swallowing," wrote Barclay, "begins with the tongue, but where does it end? I suggest that this complex, co-ordinated act extends through a segment the lower end of which is the junction of the upper and middle thirds of the esophagus."

With this illuminating suggestion we are inclined to agree, except that we would place the dividing line a few inches higher, at the junction of the hypopharynx and the esophagus.

Barclay's choice of the more distal point was based on these considerations: The bolus slows down near the level of the clavicle. Secondary peristalsis, when there is any, begins only a trifle lower. There is a change from striated to smooth muscle. The muscularis mucosae becomes a prominent feature, and the nerve supply changes. It is here that coins, etc., which have got through the pharynx sometimes lodge.

These facts all have meaning for the student of the esophagus, but are they evidence that the act of swallowing ends where Barclay suggests? He calls the act complex and co-ordinated. Is there anything particularly complex or co-ordinated about the behavior of the upper third of the esophagus? The special complexity of swallowing would appear to be limited to the region above the esophagus, where two essential functions must be carried out in the same lumen and by the same structures. In our view, the act of swallowing ends in the hypopharynx when the cricopharyngeus contracts on the tail of the bolus, thereby signalling to the proximal swallowing apparatus that it can either return to the resting stage or begin a new swallow.

*The Continuation of the Stripping Wave in the Esophagus:* No sooner has the strip-

ping wave passed through the hypopharynx than it loses its former "relentless" character and becomes quite unpredictable by pharyngeal standards. To mention only one example, if the subject swallows again while the wave is still in transit, the entire esophagus promptly relaxes, and the wave disappears. Templeton points out that in rapid drinking the whole length of the esophagus and cardia may remain inhibited, so that the fluid falls in spurts from the hypopharynx into the stomach, unescorted by any esophageal peristalsis whatever. When the same experiment is repeated in a very mild Trendelenburg position, to eliminate, as far as possible, the effect of gravity, the proximal swallowing apparatus can be seen propelling a column of fluid through the passive gullet, like a force pump. The present paper is not the place for a description of esophageal dynamics, but perhaps enough has been said to show that the third stage of swallowing is a necessary sequel to the swallowing act rather than an integral part of it.

#### IV. FURTHER DETAILS AND VARIATIONS

*The Fate of Pharyngeal Air:* As previously mentioned, some of the air trapped in the laryngeal pharynx ahead of the bolus vanishes through the still open glottis (Fig. 5A). If the subject is erect, a variable quantity of air tends to collect above the bolus in the oral pharynx. By the time this air has been carried downward by the stripping wave into the laryngeal pharynx, the glottis is closed, and air and bolus pass into the esophagus together. This is also what happens to the much larger volumes of air gathered by the tongue and forced into the pharynx during aerophagia.

With the subject in Trendelenburg position, all of the trapped air tends to gravitate to a place ahead of the bolus. Some of it makes its exit through the glottis, while the remainder precedes the bolus into the esophagus, like a sort of *caput succedaneum*. It is safe to say that the proportion of trapped air diverted

through the glottis into the trachea is relatively small, under normal conditions.

In patients with respiratory paralysis who have learned the technic of glossopharyngeal breathing, a very different type of "air swallowing" is observed. Cinefluorographic studies by Rehman of some of these patients, included in a recent film on the subject (22), show that the cricopharyngeus muscle remains contracted throughout the procedure, so that the "swallowed" air, instead of entering the esophagus, is all forced through the open glottis into the lungs. Between gulps, the glottis closes like a valve to prevent the escape of air, which is not exhaled until the lungs have been adequately inflated by a prolonged series of rapid swallowing movements. The use of this breathing technic makes it possible for the patient to do without artificial breathing aids for a considerable period.

*Gravity:* The ability of the swallowing mechanism to move food and drink toward the stomach without help from gravity, and even in opposition to gravity, is well known. What is not so often commented on is the mechanism's ability to control the downward flow of liquids. Drink does not just run down the throat; on the contrary, it has to pass through a series of valves or traps. The first of these guards the entrance of the oral pharynx, and the second is in the hypopharynx. The third, and least predictable, is at the cardia, and need not be considered here.

The pause of the bolus on the dorsum of the tongue before swallowing begins is under voluntary control and may last for some time while breathing continues through the nose. Even if the subject has decided beforehand to swallow immediately, there is still an appreciable interval after the liquid has been taken into the mouth before it is permitted to enter the oral pharynx. On the other hand, the delay of liquid in the pharynx above the contracted cricopharyngeus muscle is usually very brief indeed, since it involves only the leading part of the liquid, which has raced ahead of the rest. A more prolonged

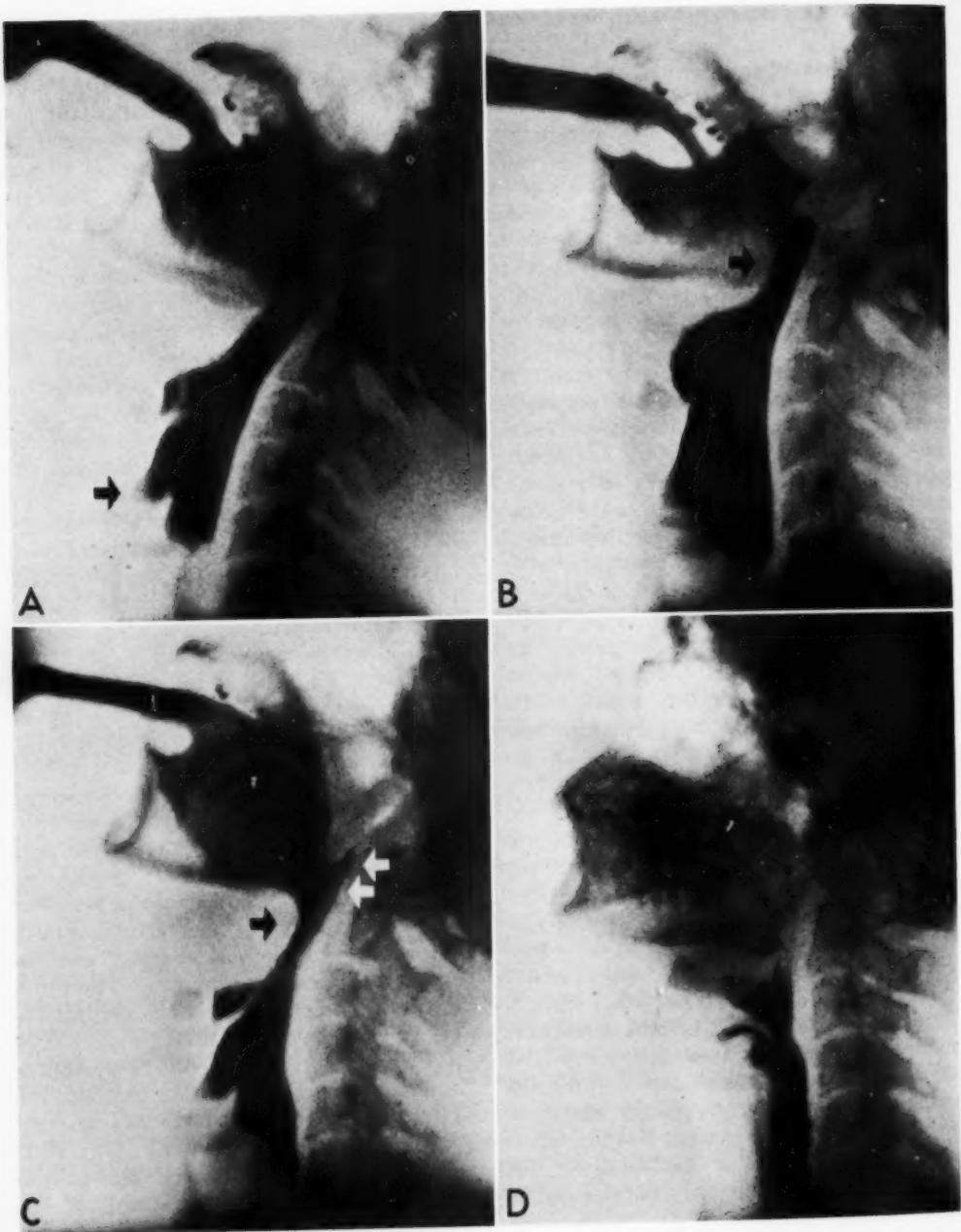


Fig. 12. Special swallowing technic used by competitive beer drinkers. Male, age 26. Liquid barium suspension.

A. Fluid is being poured from a glass into the wide open mouth. The oral pharynx is open, permitting the laryngeal pharynx to fill by gravity. The soft palate is elevated. Note the extremely low position of the tongue, hyoid bone, and larynx. The epiglottis is upright. The laryngeal vestibule, below it, is distended with barium (arrow).

B. The dorsum of the tongue bulges backward in the upper part of the oral pharynx to begin the stripping action (arrow). The barium in the oral pharynx is forced downward into the already distended laryngeal pharynx. The hypopharynx is still closed, but is about to open. A small amount of barium has penetrated the laryngeal ventricle.

holding action is occasionally seen during gargling, when some of the liquid leaks past the closed fauces and the back of the tongue into the pharynx. Here it collects in close proximity to the open laryngeal vestibule until a furtive swallowing gesture, which manages to leave the bulk of the fluid in the mouth, permits the cricopharyngeus to open. Gargling has to stop momentarily while the glottis closes, but may be resumed, if the garger does not panic, as soon as the stripping wave has contracted the hypopharynx on the tail of the swallowed liquid.

Probably the most striking example of the mechanism's ability to control a large volume of liquid is seen in the special technic of the beer drinker (Fig. 12). Liquid is literally pumped from the reservoir of the open mouth through the laryngeal pharynx, while the oral pharynx and hypopharynx open and close alternately like valves. There is no doubt here that the mouth is filled by gravity from the glass, the pharynx from the mouth, and the esophagus from the pharynx, but the filling takes place in stages, not continuously. In the last stage, the force of gravity is much augmented by the stripping action of the tongue and soft palate in the oral pharynx.

*Repetitive Swallowing of Liquids:* Our description of swallowing is based on single swallows, that is, on swallows begun after breathing and ended with a return to breathing. If the subject goes on to swallow again without stopping to breathe (and he is free to do so as soon as the hypopharynx has closed on the tail of the bolus), no air remains in the lumen, and the double contrast effect is lost. Between the first and second (or second and third) swallows, there is no return to the resting stage. Hence there is no opening of the glottis, no expansion of the pharynx with air, and no flipping back of the epiglottis from its

inverted position (10). The larynx and pharynx drop down slightly, but not to resting position, and the lumen remains contracted until the next bolus is started on its way by the tongue. During each stripping wave the liquid which has penetrated the laryngeal vestibule may recede a little (Fig. 7A), but is not squeezed completely out until the final swallow.

This kind of drinking is natural to human beings of all ages and to many animals, when they are thirsty or otherwise in a hurry. A much more reckless form of the technic has been developed by specialists in competitive beer drinking.

*An Example of Trained Swallowing:* The expert beer drinker who has taught himself to empty his glass "at one gulp" extends the head and neck in order to take advantage of gravity. Liquid is poured into the wide open mouth at a rate sufficient to keep the "fluid level" even with the lower lip. Before any liquid has passed the fauces, the whole assembly of hyoid bone, larynx, pharynx, etc., including the base of the tongue, drops rapidly downward from resting position about the thickness of a vertebral body—as in yawning.

The greater part of the tongue is now below the mandible, occluding the elongated lumen of the oral pharynx, and leaving more room in the mouth than usual. At first the leading edge of the liquid is wedged between the tongue and the depressed soft palate. However, as soon as the mouth is filled, the dorsum of the tongue moves forward, away from the posterior pharyngeal wall, the soft palate is elevated, and a large quantity of liquid flows down from the mouth and fills the oral and laryngeal pharynx as it might fill a bottle (Fig. 12A).

At this point, the tongue, assisted by the soft palate, begins to strip the oral pharynx with a series of cam-like, stroking motions

C. The black arrow points to the nearly completed, cam-like, stripping action of the tongue. The soft palate has been pulled downward to take part in the stripping action. The contracted posterior pillars are indicated by the white arrows. The hypopharynx has opened, and much of the contents of the pharynx has passed into the esophagus. Note that the posterior wall is thicker than in the preceding views.

D. The final swallow after the glass has been drained. Note that the mouth is closed, the hyoid and larynx elevated, and the epiglottis folded over.

which are repeated about once a second as long as any liquid remains in the glass (Fig. 12, B and C). Each time the oral pharynx is stripped, there results a truly remarkable distention of the laryngeal pharynx and also of the hypopharynx, which opens to pass the liquid into the esophagus. Between waves the oral pharynx is permitted to expand and fill again from above, while the laryngeal pharynx, only partly cleared, and now blocked off again from the esophagus by contraction of the hypopharynx, also expands and fills. The glottis is evidently closed throughout most of the procedure, but the laryngeal vestibule undergoes the same extreme distention with liquid as the pharynx. The epiglottis remains upright, a fact which is probably explained by the low position of the larynx. Only after the glass has been drained does the usual swallowing mechanism assert itself as a sort of final gesture, with closing of the jaws, elevation of the larynx, folding over of the epiglottis, and a long stripping wave which travels from mouth to esophagus and clears the lumen of residue (Fig. 12D).

Taken altogether, this unusual version of swallowing can perhaps be best interpreted as a series of repetitive swallows in which the successive stripping waves are confined pretty well to the oral pharynx. The laryngeal pharynx is not stripped clean until the final swallow, nor is there any sign of a traveling indentation of the posterior wall. On the contrary, the posterior wall lies nearly flat against the spine, and is obviously being stretched in order to keep the pharynx in its low position during extension of the head and neck. The constrictor muscles above the cricopharyngeus do little more than alternate between states of extreme and average relaxation.

*Swallowing of Pastes:* A number of variants are seen when a relatively dry barium paste is swallowed that adheres to the surfaces and is difficult to move. In an effort to deliver the adherent bolus into the pharynx, the soft palate and upper pharyngeal sphincters go through repeated forceful contractions against equally forceful con-

tractions of the tongue. The hyoid bone stays up under the mandible, moving jerkily backward and forward with the efforts of the tongue, and also rocking and tilting itself into most unusual attitudes. All the muscles may suddenly relax as the subject takes a breath, even though the lumen surfaces are heavily coated with paste. The opening of the larynx is accompanied by a forceful flip-back of the epiglottis, carrying on its upper surface a mass of material which, a moment before, had appeared to be hopelessly choking the airway of the laryngeal pharynx (Fig. 11C).

Studies like the above, of swallowing under difficulties, are interesting in themselves. They also help the observer by exaggerating routine actions and relationships which he might miss if he observed only the tamer versions of swallowing.

*Age Changes:* In elderly subjects the pharyngeal lumen often appears dilated and thin-walled, both when filled with air in the resting stage and with barium while swallowing. The folding over and recovery of the epiglottis may take place with difficulty. In the anterior view there is apt to be asymmetry of filling. The prominence of the lateral pharyngeal pouches has already been mentioned. Co-ordination of the swallowing movements seems less smooth in older subjects. These are general impressions, to be followed and analyzed more carefully.

*Timing:* The description of the sequence of events has been handicapped by the lack of a reliable reference point. We feel that the head of the bolus column is too variable for the purpose. The tail of the bolus, which travels in close contact with the stripping wave, is more satisfactory, but not entirely so in view of the frequent presence of a large air bubble. Our experience with pharyngeal pressures is not extensive nor accurate enough to be of much help. We have, of necessity, tried to relate to one another the various changes that have been observed, and in such a way that the general pattern is understood. We believe that there is a basic

co-ordination of function that varies considerably in individuals and with the amount and consistency of the bolus. In cinefluorographic studies the accurate number of frames per second allows the timing of events with any one swallow, but fails, when charted, to give a consistent, timed sequence of events from subject to subject.

Many factors play a part in the determination of the rate of travel of the bolus. The obvious ones have been mentioned, and their role elaborated. A wide variation of speed of passage of the bolus has been observed in normal subjects swallowing thick mixtures of identical consistency, especially when they are not given time to chew and mix the bolus with saliva. This brings out the importance of the physiological state of the mucous membranes (1), and recalls what is already well known to people who drink with their meals, namely, that adequate lubrication is a prerequisite.

#### SUMMARY

1. As a topic of anatomical physiology, the act of deglutition was studied by some of the ablest 18th century physiologists. Magendie's revision and summary of their views in 1817 predated by many years the discovery of the reflex nature of the mechanism. Nevertheless, this early outline of the major events of swallowing has never been successfully challenged, and, so far as it goes, is considered valid today.

2. Slow motion cinefluorography now makes it possible to check inferences and generalizations against records of what "actually happens" in particular swallows. The new method should eventually provide a reliable x-ray motion standard or test of normal swallowing.

3. Considered purely from the point of view of food transport, the various moves and countermoves of the swallowing organs fall into two classes: those which expand the food channel to make room for the bolus and those which contract the channel on the tail of the bolus and "strip" it toward the esophagus. The two waves (of expansion and contraction) can be seen

traveling from the mouth to the esophagus with each swallow, provided the observer has learned what to watch for at the different levels.

4. Side by side with the action which transports the food, there is the overlapping action which protects the air passages. The movements of the soft palate serve both purposes, but the elevation of the larynx and pharynx and the inversion of the epiglottis are almost exclusively protective. For obvious reasons, the swallowing act loses much of its complexity in laryngectomized subjects.

5. With the exception of a few constant reflex relationships, both the timing and order of the swallowing events vary considerably in different individuals, and in the same individual under different conditions. Other variations develop with age. There are also persons who, by habit or training, deviate markedly from the usual mechanism. All this must be taken into account when trying to distinguish between the unusual and the abnormal. The present discussion, which owes much to the work of others, is the sum of our knowledge at the moment. We believe that a great deal is still to be learned by continuing the motion study of normal and abnormal swallows, and by combining it with other research methods.

NOTE: The authors gratefully acknowledge the editorial assistance of Mr. William Cornwell and Mrs. Marion Young in the preparation of this paper, and of Mr. Boyd W. Thomas and Mr. Karl Sutter in the taking and processing of the films on which it is based.

University of Rochester  
School of Medicine and Dentistry  
Rochester 20, N. Y.

#### REFERENCES

1. BOERHAAVE, H.: Dr. Boerhaave's Academical Lectures on the Theory of Physic, Being a Genuine Translation of the Institute and Explanatory Comment, London, 1751.
2. HALLER, A. V.: First Lines of Physiology. Translated from the 3rd Latin edition of *Prima Liniae Physiologiae*. 1st American edition, Troy, 1803.
3. OLMSSTRAD, J. M. D.: Francois Magendie. New York, Henry Schuman, Inc., 1944.
4. MAGENDIE, F.: A Summary of Physiology. Translated from the French by John Revere, Baltimore, 1822.
5. KRONECKER, H., AND MELTZER, S.: Über der

- Vorgänge beim Schlucken. Arch. f. Physiol., 1880, pp. 446-447, and Suppl., 1883, pp. 328-360.
6. CANNON, W. B., AND MOSER, A.: The Movements of Food in the Esophagus. Am. J. Physiol. 1: 435-444, 1898.
  7. MOSHER, H. P., AND MACMILLAN, A. S.: X-Ray Study of Movements of the Tongue, Epiglottis, and Hyoid Bone in Swallowing, Followed by Discussion of Difficulty in Swallowing Caused by Retropharyngeal Diverticulum, Posterior Webs and Exostoses of Cervical Vertebrae. Laryngoscope 37: 235-262, April 1927.
  8. BARCLAY, A. E.: The Normal Mechanism of Swallowing. Proc. Staff Meet. Mayo Clin. 5: 251-257, Sept. 10, 1930.
  9. BARCLAY, A. E.: The Digestive Tract. A Radiological Study of Its Anatomy, Physiology and Pathology. New York, The Macmillan Co., 1936.
  10. JOHNSTONE, A. S.: A Radiological Study of Deglutition. J. Anat. 77: 97-100, October 1942.
  11. RUSHMER, R. F., AND HENDRON, J. A.: The Act of Deglutition: A Cinefluorographic Study. J. Appl. Physiol. 3: 622-630, April 1951.
  12. SAUNDERS, J. B. DE C. M., DAVIS, C., AND MILLER, E. R.: The Mechanism of Deglutition (Second Stage) as Revealed by Cine-Radiography. Ann. Otol., Rhin. & Laryng. 60: 897-916, December 1951.
  13. TEMPLETON, F. E.: X-Ray Examination of the Stomach: Description of Roentgenologic Anatomy, Physiology, and Pathology of Esophagus, Stomach, and Duodenum. Chicago, University Press, 1944.
  14. JANKE, R.: Roentgen Cinematography. Am. J. Roentgenol. 36: 384-390, September 1936.
  15. ARDRAN, G. M., AND KEMP, F. H.: The Protection of the Laryngeal Airway During Swallowing. Brit. J. Radiol. 25: 406-416, August 1952.
  16. ARDRAN, G. M., KEMP, F. H., AND TRUELOVE, S. C.: A Radiological Study of Acrosclerosis. Gastroenterology 79: 361-375, 1953.
  17. RAMSEY, G. H. S., WATSON, J. S., JR., STEINHAUSEN, T. B., THOMPSON, J. J., DREISINGER, F., AND WEINBERG, S.: Cinefluorography. A Progress Report on Technical Problems, Dosage Factors, and Clinical Impressions. Radiology 52: 684-690, May 1949.
  18. BAYLISS, W., AND STARLING, E. H.: The Movements and Innervation of the Small Intestine. J. Physiol. 24: 99-143, 1899, and 26: 125-138, 1901.
  19. KILLIAN, G.: La bouche de l'oesophage. Ann. d. maladies d. l'oreille et du larynx. 34: 1, 1908. Quoted by Barclay (9).
  20. NEGUS, V. E.: Affections of the Cricopharyngeal Fold. Laryngoscope 48: 847-858, December 1938.
  21. NEGUS, V. E.: The Comparative Anatomy and Physiology of the Larynx. New York, Grune & Stratton, 1949.
  22. DAHL, C. W., AND AFFELDT, J. E.: Glossopharyngeal Breathing. A medical teaching film from the Department of Visual Education, College of Medical Evangelists, Los Angeles. One reel, 16 mm. color. Available from Motion Picture Service Bureau, 2057 Bragg St., Brooklyn 29, N. Y.

## SUMARIO

## Análisis Cinefluorográfico del Mecanismo de la Deglución

Emprendiéronse estudios cinefluorográficos del mecanismo de la deglución en unas 300 personas, aproximadamente la mitad de las cuales eran consideradas normales. Se hicieron exámenes en varias posiciones con una mezcla de sulfato de bario y agua como medio de contraste. Se usó película de 35 mm. con la cámara a velocidades de 30 y 60 exposiciones por segundo.

Considerados puramente desde el punto de vista del transporte de alimento, los varios movimientos propulsores y retrógrados de los órganos deglutivos corresponden a dos clases: los que expanden el conducto alimenticio para acomodar el bolo (por lo cual se sobreentiende la porción de las materias introducidas en la boca que separa la lengua para formar un solo bocado) y los que contraen el conducto detrás del bolo y empujan o comprimen éste hacia el esófago. Las dos ondas (de expansión y contracción) pueden observarse marchando de la boca al esófago con cada bocado, con tal que el observador haya aprendido lo que debe tratar de ver a los distintos niveles.

A la par de la acción que transporta el alimento, tenemos la acción sobrepuerta que protege las vías aéreas. Los movimientos del paladar blando cumplen ambos propósitos, pero la elevación de la laringe y la faringe y la inversión de la epiglotis son acciones casi exclusivamente protectoras.

Exceptuadas algunas constantes relaciones reflejas, tanto la cronología como el orden de los acontecimientos deglutivos varían considerablemente en distintos individuos y en el mismo individuo en distintas circunstancias. Otras variaciones aparecen con la edad. Hay además personas que, por hábito o adiestramiento, se apartan decididamente del mecanismo habitual. Todo esto debe ser tomado en cuenta al tratar de diferenciar entre lo extraño y lo anómalo. La reseña actual, que debe mucho a la labor ajena, es el resumen de nuestros conocimientos hoy día. Resta mucho todavía que aprender continuando el estudio de los movimientos de la deglución normal y anormal y combinando esto con otros métodos investigativos.

## Roentgen Characteristics of Osteogenic Sarcoma of the Jaw<sup>1</sup>

ROBERT S. SHERMAN, M.D., and MYRON MELAMED, M.D.

SARCOMAS OF THE jaw, like sarcomas in other portions of the skeleton, may offer a difficult diagnostic task for the roentgenologist. The problem of adequately demonstrating lesions affecting the jaws and the need to differentiate between the tumor and diseases peculiar to the dental structures are more or less serious additional factors to be considered. Furthermore, the jaws are especially prone to invasion by malignant growths arising in neighboring organs and tissues.

Most workers dealing with bone sarcoma classify their material upon a histologic rather than a radiologic basis. At Memorial Hospital all services adhere fairly closely to Ewing's classification (5), which subdivides osteogenic sarcoma as follows: medullary, telangiectatic, sclerosing, medullary fibrosarcoma, and periosteal fibrosarcoma. The chondroma series is represented on the malignant side solely by chondrosarcoma.

Pancoast *et al.* (7) reported three sarcomas of the jaws, each of which showed both sclerosing and osteolytic manifestations. These writers did not observe any chondrosarcomas in the mandible. Sarcomas of the antra in their series were defined as small-cell, round-cell, or spindle-cell types. In general, they were expanding rather than invasive lesions. It was not clear, however, that all these antral tumors actually arose in bone.

Geschickter and Copeland (6) classified their sarcoma cases as of osteogenic and Ewing's types. The osteogenic varieties they further subdivided into sclerosing forms and osteogenic sarcoma containing cartilage. It may be noted in passing that 19 of their 36 cases of sarcoma of the jaw were listed as Ewing's tumor. Our experience, however, is not in accord with this observation, inasmuch as no Ewing's

tumor primary in the jaw is listed in our files.

Thoma (10) divides sarcomas of the jaw into fibrosarcoma and osteogenic sarcoma. The fibrosarcoma group includes peripheral and central varieties, and the osteogenic group osteolytic and osteoblastic types.

It is evident that those pathologists having a wide experience in neoplasia of bone can be relied upon to be more regularly accurate and dependable in their diagnosis of bone tumors. Furthermore, pathological interpretation of many bone lesions is still evolving, and diagnoses made a decade or more ago may not be verified by today's standards. For example, we have seen a lesion labeled a number of years ago as fibrosarcoma of bone now reclassified as fibrous dysplasia. A well documented origin within the bone is occasionally necessary in order to establish the tumor as definitely belonging to the osteogenic group, and this may be somewhat more difficult to establish in the jaw than in other bones. Because of incomplete gross pathological studies or inadequate x-ray film coverage, needed information along this line has been lacking in the past in some instances. For reasons such as these the atypical group in the present study may appear disproportionately large. Until the clinical, roentgenologic and pathologic observations are all in agreement, one must have reservations about any individual diagnosis of bone neoplasm.

The series reported here consists of 19 "typical" osteogenic sarcomas, in which the clinical features, x-ray diagnosis, and histologic interpretation offered satisfactory correlation, and 7 additional tumors which present one or more unusual aspects.

In the "typical" group there were 8

<sup>1</sup> From the Department of Diagnostic Roentgenology, Memorial Center, New York, N. Y. Accepted for publication in April 1954.

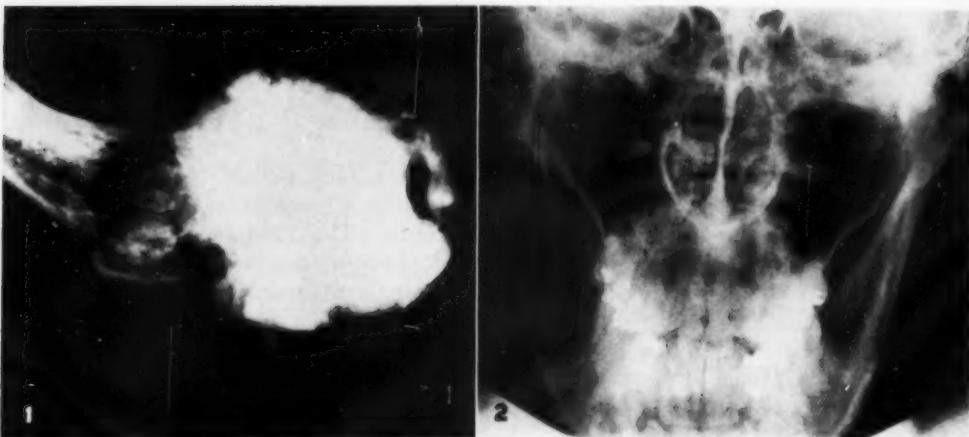


Fig. 1. Sclerosing osteogenic sarcoma.  
Fig. 2. Lytic form of osteogenic sarcoma.

males and 11 females. The maxilla was involved in 4 cases and the mandible in 15. The youngest patient was fifteen years of age and the oldest sixty-seven. Seven patients were between twenty-one and thirty years old. Symptoms were of relatively short duration, 11 patients having had complaints for three months or less and none for more than a year. In 17 the chief complaint was a mass. Other statements concerned pain, numbness, "soreness of teeth," and tooth displacement. It is worthy of note that 14 patients consulted dentists either originally or very early in the course of their disease.

In attempting to diagnose osteogenic sarcoma of the jaws roentgenologically, we have evolved a broad grouping consisting of three principal types: the sclerosing, the lytic, and the mixed. As far as we can learn, only the first of these is more or less closely related to a histological type, *viz.*, the sclerosing osteogenic sarcoma.<sup>2</sup> The lytic group may include the subvarieties labeled histologically as medullary osteogenic sarcoma, medullary fibrosarcoma, telangiectatic osteogenic sarcoma, and chondrosarcoma. The mixed

may be related to the same histologic forms as the lytic, the chondrosarcoma being encountered relatively more frequently.

It will be seen that such a simple x-ray classification makes no serious effort to separate chondrosarcoma from osteogenic sarcoma, an accomplishment that in our experience can be dependably achieved by the roentgenologist only in special circumstances. Furthermore, while some might wish histologically and clinically to separate the two varieties, medullary and periosteal fibrosarcoma, from other osteogenic sarcomas, there are insufficient grounds at this time upon which to attempt a segregation of these varieties roentgenologically.

Radiographically, the sclerosing osteogenic sarcoma presents as its main feature a predominance of dense structureless eburnated bone (Fig. 1). In the lytic form destruction predominates over production of bone, and usually no density may be expected (Fig. 2). The mixed type presents approximately equal amounts of destruction and production (Fig. 3). Added to these special characteristics, which constitute the basis of the roentgen classification, are the many individual points which, considered together, may make an x-ray diagnosis of osteogenic sarcoma possible. Briefly, and as related

<sup>2</sup> Dr. Arthur C. Allen of the Pathology Laboratories at Memorial Center reviewed the problem tumors and offered advice on the correlation of the roentgenologic and histologic findings.

to the present discussion, these are a medullary origin, an asymmetrical position in the bone, medullary and cortical bone destruction, periosteal reaction of various types, ill-defined borders, an oval or pear shape, a soft-tissue mass, and a disorganized pattern of internal structure.

Our detailed study of the roentgen characteristics of osteogenic sarcoma (and chondrosarcoma) of the jaw has been approached from the standpoint of the roentgen classification. The earliest available films have been used, and if subsequent studies were made, an appraisal of the growth rate and the treatment effect has been carried out.

The "typical" group included 3 sclerosing osteogenic sarcomas. Histologically 2 were called osteochondrosarcoma and 1 osteogenic sarcoma. Two were in the body and 1 was in the ramus of the mandible. These tumors measured about 5 cm. They were oval in shape, with some marginal lobulation in 1. All showed a perpendicular type of periosteal reaction, of moderate to extensive degree, and all were accompanied by a soft-tissue mass, described as small to moderate in size. The borders were indistinct; the origin was medullary, 1 tumor being fairly symmetrical in location in the jaw. All presented cortical destruction. In 2 cases teeth were present, but loss of the lamina dura was the only evidence of an effect of the new growth.

A three-month interval film survey, made in 1 of these sclerosing sarcomas, seemed to reveal about a 10 per cent increase in size.

In the lytic group there were 6 tumors. All were in the mandible. All except 1 were diagnosed histologically as osteogenic sarcoma, the exception being diagnosed chondrosarcoma. The average size was about 5 cm. Three new growths were in the ramus, 1 was at the angle, and 2 were in the body of the mandible. All were oval in shape except 1, which was spherical. Only 1 showed a definite periosteal reaction, and this was of the layered type. There were no fractures. Each of the 6



Fig. 3. Mixed form of osteogenic sarcoma.

lytic osteogenic sarcomas was associated with a soft-tissue mass. Two of the soft-tissue extensions were large, 2 moderate, and 2 small in comparison with the area of tumor involvement within bone. One of these soft-tissue extensions showed a slight amount of amorphous calcification. Borders of the neoplasms were indefinite and indistinct except for 1 tumor, which demonstrated some sharpness of margin. All the lytic tumors seemed to arise from the medullary portion of the jaw, and all were asymmetrically positioned. Destruction of the cortex was always observed, usually of wide extent. The lamina dura was lost in the 2 tumors in which teeth were in contact with the neoplasm.

One osteogenic sarcoma followed roentgenographically for one month showed a little growth, with the formation of fragments of calcification. Another showed continued enlargement after teleradium therapy, becoming about 30 per cent larger in four months.

Ten osteogenic sarcomas were put into the mixed category on the basis of their roentgen appearance. These were the tumors that presented approximately equal amounts of destruction and production as seen on the film. Six were diagnosed histologically as osteogenic sarcoma and four as chondrosarcoma. These tumors averaged 4.5 cm. in diameter. Two of the smallest osteogenic sarcomas were in this category, measuring not over 2 cm. Four were located in the body and 3 in the ramus.

of the mandible, and 3 more in the maxilla. Seven were oval and 3 were spherical in configuration. Six revealed periosteal reaction, either layered or perpendicular in form. Only 1 tumor of the mixed type failed to show a soft-tissue mass. The soft-tissue extensions were small, moderate, or large. All of the new growths showed ill-defined borders, but in 1 a portion of the periphery was quite well defined.

In 2 cases some doubt existed as to whether the origin of the tumor was periosteal or medullary, but in the rest a medullary origin seemed clear. Two tumors were fairly symmetrical; the rest were asymmetrical. In all mixed osteogenic sarcomas some degree of cortical destruction was identified. Three tumors were in contact with teeth. In 1 of these no effect was noted; in another there was loss of the lamina dura and in the last both displacement and loss of lamina dura were seen.

Two osteogenic sarcomas were observed roentgenographically over a period of time. In one seen eleven months after radiation treatment, the tumor seemed somewhat denser but appeared to be no larger. A second increased in size tenfold in a period of three months.

The detailed aspects of differential diagnosis are to be considered on the basis of the three divisions of the roentgen classification. Generally speaking, it is our opinion that the radiographic appearance of the typical well developed sclerosing osteogenic sarcoma is just about pathognomonic. Pathological confirmation is always necessary, however, before definite treatment is undertaken. The characteristic x-ray appearance of these sclerosing sarcomas may at times be helpful in establishing the true nature of the lesion, since limited biopsy material may simply resemble dense eburnated bone (2). The occurrence of plentiful periosteal reaction makes roentgen interpretation easier. It is conceivable that metastasis from a prostatic carcinoma might closely simulate sclerosing osteogenic sarcoma, but metastatic disease is generally widespread by the time the jaw shows involvement.

The differential diagnosis of the lytic form of osteogenic sarcoma is complex and it appears doubtful that a specific roentgen diagnosis of osteogenic sarcoma is possible. The radiologist's problem is aggravated by the lack of a sharp separation pathologically among the neoplasms that fall into this roentgen group. In general, we believe that nothing better than a diagnosis of malignant tumor can be offered. Metastatic cancer, cancer directly invading bone from nearby organs, certain other primary malignant bone tumors, lymphoblastoma in bone, neuroblastoma—all these are neoplasms more or less difficult or impossible to exclude completely. Under certain special circumstances, epulis also must be differentiated from osteogenic sarcoma. Infections such as osteomyelitis, syphilis, and others, may occasionally resemble the lytic form of osteogenic sarcoma roentgenographically. Finally, there are accounts in the literature of osteogenic sarcoma bearing a close roentgen resemblance to certain benign lesions of bone (8, 9), such as the different varieties of cysts.

What has been said concerning the differential diagnosis of the lytic form of osteogenic sarcoma holds generally for the mixed type. However, only those metastases known to produce some degree of increased density would need to be considered. Also a number of types of direct cancer invasion are regularly osteolytic, serving to narrow the field a little more. Most of the infections of bone would still have to be considered, as would the lymphoblastomas. It seems that here again the most that the roentgenologist can regularly accomplish is a diagnosis of malignant tumor affecting the jaw bone.

#### CASE REPORTS

CASE I: R. E., 11-year-old white male, complained of swelling of the left cheek for six months. Bulging was noted, but there was no pain or tenderness. The roentgen examination revealed a well defined lesion,  $6 \times 6 \times 5$  cm., filling the left antrum and expanding its walls. There was a fine, regular, dense cortical border about the entire process. Within the mass were many scattered calcific de-

poses several millimeters in diameter. The original roentgen diagnosis was "most consistent with ossifying fibroma" (Fig. 4). A recent pathologic review of the resected specimen favored ossifying fibroma or fibrous dysplasia and did not support the original pathological diagnosis of "a form of low grade chondrosarcoma." There is no evidence of active disease five years after onset. Repeated x-ray studies have revealed no change in a small fragment of the lesion left at the time of excision.

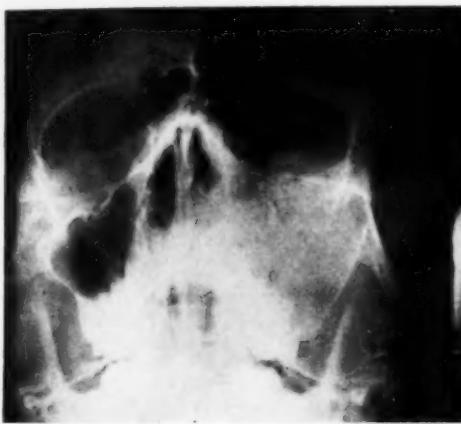


Fig. 4. Case I: A benign process of the maxilla, possibly ossifying fibroma. Original pathological diagnosis of low-grade chondrosarcoma not substantiated.

*Comment:* The roentgen diagnosis and the behavior of the lesion failed to support the original pathological opinion, which has now been revised.

**CASE II:** A. G., 52-year-old white male, had a mass on the right upper jaw for three months following tooth extractions. The patient was known to have had acromegaly for about thirty years. Examination revealed, in addition, a large mass evidently arising in the region of the right antrum and secondarily involving the floor of the orbit. Intraoral extension involved the entire right half of the superior maxilla and the hard and soft palate.

X-ray examination showed a predominantly hyperostotic change involving the right side of the mandible, the right maxilla, zygoma, and temporal bone. Within this diseased region an area of bone destruction about 2 cm. in diameter was identified in the right malar area along the alveolar margin. Radiographically, there is little doubt that two processes were present, one chondrosarcoma, represented by the destruction in the malar bone and confirmed histologically, the other a hyperostotic change which to us seems most consistent with fibrous dysplasia (Fig. 5). Review of the biopsy material revealed no suggestion of an underlying abnormality. X-ray therapy was given without



Fig. 5. Case II: A chondrosarcoma of the maxilla associated with a diffuse hyperostotic change thought to be fibrous dysplasia.

avail and the patient expired of gradually increasing disease two years after onset.

*Comment:* The roentgen examination, in addition to giving information as to the extent and character of the new growth, also showed that the malignant tumor arose in abnormal bone, probably in an area of fibrous dysplasia.

**CASE III:** M. C., 43-year-old white male, was admitted with a six months history of enlargement of the mandible. Seven years before he had been told that he had a "bone cyst." At that time several teeth were extracted by a dentist and the bone was "scraped." Physical examination of the area revealed enlargement of the body of the right side of the mandible. Aspiration biopsy favored a primary bone tumor, probably of medullary spindle-cell type. A formal biopsy of the involved area revealed a non-bone forming spindle- and giant-cell osteogenic sarcoma of a virulent type. The possibility of a malignant change in a previously benign tumor was suggested by the presence of relatively torpid fibromatous appearing foci.

Radiographically this tumor was seen as a spherical lesion asymmetrically situated in the body of the mandible. A small soft-tissue mass was identified, but no periosteal reaction was seen. Borders were for the most part distinct, the cortex being expanded and thinned. A number of fine septa were present.



Fig. 6. Case III: The appearance favors a benign process such as fibrous dysplasia, with an associated malignant change at the area of cortical destruction.

At one small point the fine margin was broken and the outline was indistinct. The origin was almost certainly medullary. The roentgen appearance was interpreted as favoring a diagnosis of fibrous dysplasia (Fig. 6).

A significant follow-up was not obtained, the therapy suggested being refused.

*Comment:* The exact nature of this tumor seems unclear. In the face of the roentgen appearance, a diagnosis of medullary spindle-cell sarcoma alone does not seem entirely satisfactory. However, the possibility of origin of a malignant tumor in fibrous dysplasia would be in keeping with all the roentgen features.

CASE IV: M. R., 42-year-old white female, was admitted with numbness and swelling of the lower jaw of ten months duration. A diagnosis of malignant tumor had been made nine months previously, after which the tumor was removed and a course of x-ray therapy administered. The present examination revealed superficial irregularity of the mucous membrane of the left lower gingiva. Absence of teeth was noted. Submitted slides showed spindle-cell sarcoma (Figs. 7 and 8).

X-ray films demonstrated an oval area of involvement,  $5 \times 4 \times 3$  cm., near the angle of the mandible. A moderate-sized soft-tissue mass was present. Borders were ill-defined and the position in the bone was asymmetrical. Origin seemed to be from the

bone itself. The cortex was eroded, and the lamina dura of adjacent teeth was lost. The tumor presented lingually. There were ragged, ill-defined septa traversing the area of destruction, producing a roentgen appearance which led to an incorrect diagnosis of adamantinoma (Fig. 9).

There was no evidence of disease five years after surgery.

*Comment:* Just where this lesion belongs does not seem clear at this time. Neither pathological material nor roentgen diagnosis seemed to indicate osteogenic sarcoma of the usual variety.

CASE V: J. H., 58-year-old white female, was admitted with a swelling of the lower jaw present for three months. A large mass was noted on the right protruding into the mouth and associated with ulceration.

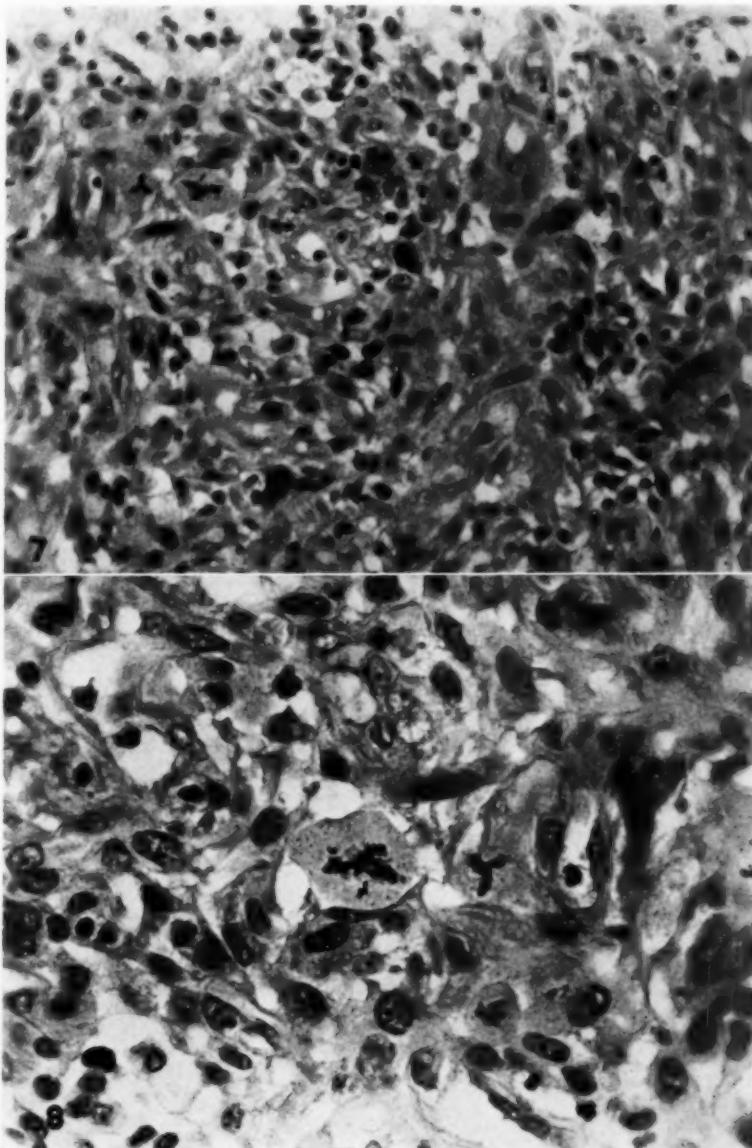
Roentgen study revealed a  $7 \times 7 \times 6$ -cm. tumor situated in the ramus and angle area of the mandible, spherical and of moderate size. The process was osteolytic and apparently of medullary origin, though an extrinsic origin was possible. The position was asymmetrical, with presentation in the mouth. The unusual roentgen feature was the distinctness of the margins in bone (Fig. 10). After radiation treatment, a slight productive change characterized by the appearance of septa took place.

Biopsies revealed low-grade fibrosarcoma. Treatment was by radium pack and radon seeds. The patient expired seven years after onset, of gradually increasing disease. The details of the course are not known.

*Comment:* The distinct margins of the lesion in bone and the biopsy diagnosis of fibrosarcoma suggest a possible extrinsic origin. The survival time with radiation treatment alone is unusual for osteogenic sarcoma.

CASE VI: L. F., 40-year-old white male, was admitted with a swelling of the lower jaw present for two years. A tumor was noted, distending the left ramus and the body of the mandible, involving the mucosa in one area with ulceration. Several teeth were missing in the involved region.

X-ray studies revealed an  $8 \times 4 \times 4$ -cm. abnormality in the ramus and angle of the mandible. There was no periosteal reaction, but a moderate-sized soft-tissue mass was present. The lesion was of the lytic variety, with quite distinct borders. Radiographically we could not determine whether an intrinsic or an extrinsic origin was to be favored. The cortex was destroyed, thinned, and expanded in different areas, and the tumor was asymmetrically placed. Radiation treatment was without demonstrable effect, and the tumor continued to enlarge.



Figs. 7 and 8. Case IV: Spindle- and giant-cell sarcoma of jaw. Numerous mitotic figures are present, including two which are tripolar. The high-power view illustrates the anaplasia of the sarcoma and the bizarre mitoses in sharp contrast to what might be anticipated from the roentgenogram.

as seen radiographically, without evidence of production except for a few fine septa. Enlargement seemed to be along the confines of the bone (Fig. 11).

Initial biopsy showed a cellular spindle-cell tumor. Roentgen therapy was followed by resection of the tumor. The pathological report was "low-grade spindle-cell fibrosarcoma, periosteal type." The

patient died one year after admission with progressive disease, but the details of the course are not known.

*Comment:* Here again the exact site of origin of the sarcoma seems to be in question.



Fig. 9. Case IV: The appearance seems unusual for osteogenic sarcoma because of the septa.

**CASE VII:** M. T., 13-year-old white male, was admitted with swelling of the right side of the face for six weeks. Teeth had been extracted two months previously. Examination revealed an upper lid paralysis of the right eye and paralysis of the extraocular muscles, excluding the lateral rectus. There was marked swelling of the right side of the face, with fullness of the nasopharynx on the right.

Roentgen examination showed a  $10 \times 8 \times 7$ -cm. area of bone destruction in the ramus of the mandible with areas of bone loss in the anterior and middle cranial fossae. A very large soft-tissue mass was present. The edges of bone destruction were distinct. There was no productive change. The point of origin of the process was not clear radiographically. Because of the bulk of the mass, which was largely extraosseous, the sharpness of the borders of bone destruction, and the presence of the two isolated areas of bone involvement, this was thought not to be the usual osteogenic sarcoma (Fig. 12). It seemed to be a tumor of extraosseous origin.

Aspiration biopsies revealed spindle-cell sarcoma. The patient received x-ray therapy but died fourteen months after admission.

*Comment:* Again the exact site of origin of this sarcoma remains unsettled.

#### SUMMARY

1. Twenty-five sarcomas with one benign tumor originally diagnosed as chondrosarcoma have been studied roentgenologically in an attempt to establish criteria for recognition of osteogenic sarcoma of the jaw bones.

2. Nineteen of the sarcomas were considered as typical, in that their clinical, roentgen, and pathological features seemed to justify a diagnosis of osteogenic sarcoma.

3. A limited x-ray classification was offered to satisfy the needs of the present study.

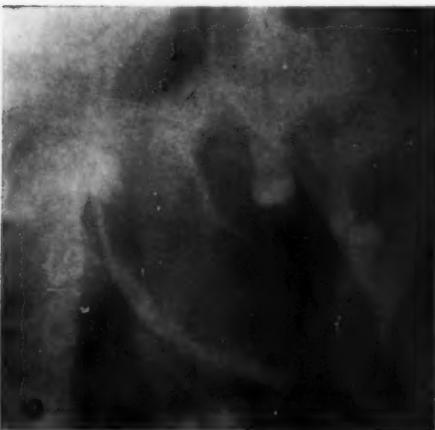


Fig. 10. Case V: The distinct margins seem a little unusual for osteogenic sarcoma, as does the long survival time with radiation treatment alone.



Fig. 11. Case VI: Roentgen appearance unusual for periosteal fibrosarcoma of bone, at least as this lesion is seen in the long bones.

4. The differential diagnosis of osteogenic sarcoma of the jaw has been discussed and the reliability of the x-ray interpretation has been considered.

5. Case reports of 7 tumors have been added to illustrate specific points and to indicate the difficulty sometimes encountered in establishing a final diagnosis in this field.

444 East 68th St.  
New York 21, N. Y.

#### REFERENCES

- ACKERMAN, L. V., AND DEL REGATO, J. A.: Cancer: Diagnosis, Treatment and Prognosis. St. Louis, C. V. Mosby Co., 1947.
- ALLEN, A. C.: Personal communication.
- BLUM, T., KALETSKY, T., AND FREUND, M.: Osteogenic Sarcoma of the Mandible. *Ann. Dent.* 3: 21-27, June 1944.
- COLEY, B. L.: Neoplasms of Bone and Related Conditions: Their Etiology, Pathogenesis, Diagnosis, and Treatment. New York, Paul B. Hoeber, Inc., 1949.
- EWING, J.: A Review of the Classification of Bone Tumors. *Surg., Gynec. & Obst.* 68: 971-976, May 1939.
- GESCHICKTER, C. F., AND COPELAND, M. M.: Tumors of Bone. 3d ed. Philadelphia, J. B. Lippincott Co., 1949.
- PANCOAST, H. K., PENDERGRASS, E. P., AND SCHAEFFER, J. P.: The Head and Neck in Roentgen Diagnosis. Springfield, Chas. C Thomas, 1940.
- SONESSON, A.: Odontogenic Cysts and Cystic Tumors of the Jaws. A Roentgen-Diagnostic and Patho-Anatomic Study. *Acta radiol. Suppl.* 81, 1950.
- TWADDELL, D.: Malignant Osseous Tumors of



Fig. 12. Case VII: Besides the area of destruction shown at the base of the skull, destruction was also seen in the ramus of the mandible.

the Jaw. *Bull. Ayer Clinic, University of Pennsylvania Hospital* 3: 495-500, 1946.

10. THOMA, K. H.: Osteogenic Tumors of the Jaws. *Ann. Roy. Coll. Surgeons England* 5: 143-157, September 1949.

11. THOMA, K. H.: Oral Pathology. A Histological, Roentgenological and Clinical Study of the Diseases of the Teeth, Jaws and Mouth. 2d ed., St. Louis, C. V. Mosby Co., 1944.

12. WINDEYER, B. W.: Malignant Tumours of the Upper Jaw. *Brit. J. Radiol.* 17: 18-24, January 1944

#### SUMARIO

#### Característica Roentgenológica del Sarcoma Osteógeno de la Mandíbula

Con mira a establecer normas para el reconocimiento del sarcoma osteógeno de la mandíbula, se estudió una serie de casos, comprendiendo 19 típicos sarcomas osteógenos y 7 que presentaban una o más características extrañas. En los casos típicos, los hallazgos clínicos, roentgenológicos e histológicos convinieron con el diagnóstico. Se agregan historias de los casos atípicos en que no se obtuvo tal acuerdo.

Reconociéronse tres formas roentgenológicas: esclerosante, lítica y mixta (esclerosante y lítica). Sólo la esclerosante corresponde a una forma histológica bien definida, a saber, sarcoma osteógeno esclero-

rosante. Las otras dos formas presentan variados cuadros histológicos.

Se considera el diagnóstico diferencial del sarcoma osteógeno de la mandíbula a base de las tres formas roentgenológicas. Unicamente la forma esclerosante presenta un cuadro típico, que parece casi patognomónico. Se manifiesta en forma de una espesa tumefacción desorganizada, casi siempre de forma oval, de bordes indistintos, asociada a una tumefacción de tejido blando y destrucción cortical.

En lo relativo a las formas lítica y mixta, el roentgenólogo poco más puede hacer que formular un diagnóstico de tumor maligno que afecta el maxilar inferior.

## Patent Ductus Arteriosus

A Critical Evaluation of Its Roentgen Signs<sup>1</sup>

THEODORE E. KEATS, M.D., and HOWARD L. STEINBACH, M.D.

WITH INCREASING experience in the diagnosis of patent ductus arteriosus it has become evident that there exist wide variations in the physiological and pathological manifestations of this congenital anomaly. It is now obvious that clinical, laboratory, and roentgen signs that have been described in the past may be atypical or absent.

The purpose of the study to be reported here was to re-evaluate the roentgen manifestations of patent ductus in the light of accumulated observations and to correlate them with the concomitant physiological and anatomic changes. It was also desired to discover the certainty with which this diagnosis can be made from plain films and to determine the correlation between the roentgen findings, size of the ductus, and age of the patient.

It has been generally agreed (1-6, 8-10) that prominence of the pulmonary artery is a most consistent finding in isolated patent ductus arteriosus. Several authors point out that this enlargement extends into the hilar shadows (6, 10) and into the peripheral pulmonary vasculature as well (1, 2, 6). Cardiac enlargement has been described (1, 4, 6, 8) and enlargement of the left ventricle emphasized (1-3, 6, 8, 10). As to the incidence of right ventricular enlargement there is little agreement: Grier (3) comments on its occurrence late in the disease, while Neuhauser and Wittenborg (7) believe that it may be seen earlier. Most surveys fail to mention its presence at all.

Left atrial enlargement has been described as a fairly consistent finding (1, 2, 6, 8), but some observers have not been able to confirm this conclusively (10, 11). Likewise, there is disagreement concerning the appearance of the aorta. Nichol and

Brannan (8) feel that there is always aortic enlargement, while Neuhauser (6) states that the aorta shows no abnormality in size or contour.

Jönsson and Saltzman (4) describe visualization of the infundibulum of the ductus as a sign of its patency. The infundibulum is a localized dilatation of the aorta at the site of origin of the ductus. It is manifested in postero-anterior chest films by loss of the concavity normally present on the left side of the aorta immediately beneath the knob and its replacement by a slight convexity or a resultant straightening. This was confirmed by Steinberg *et al.* (16) in angiograms. Steinberg and his associates also describe elevation of the main and left pulmonary arteries as an associated finding in patent ductus arteriosus.

It is agreed by most authors writing on the subject that the electrocardiographic findings in patent ductus are usually normal, although prolonged P-R intervals, left axis, and occasionally right axis deviation are also seen (5, 8, 11).

Cyanosis is apparently quite rare. In two reports it is said not to have occurred in the authors' experience (5, 8); others mention it as an infrequent finding (1, 10).

The excellent review of the roentgenology of patent ductus arteriosus by Donovan *et al.* in 1943 (1) included observations on 50 proved cases. Since that time there has been no confirming or additional work of a similar nature. The present data will, therefore, be compared with and will complement the results of these authors.

### MATERIAL AND METHODS

The data presented in this study were derived from the chest roentgenograms and hospital charts of 100 surgically proved

<sup>1</sup> From the Department of Radiology, University of California School of Medicine, San Francisco, Calif. Accepted for publication in May 1954.

cases of isolated patent ductus arteriosus seen at the University of California Hospital between 1944 and 1953. The exclusion of other congenital cardiac lesions is based upon the findings of the surgeon at the time of operation. Every roentgen examination consisted of at least an antero-posterior or postero-anterior film of the chest and a left lateral projection. In approximately one-half of the cases right and left oblique projections were also obtained.

The age and sex of each patient were noted; an evaluation was made from the chest films of cardiac size, right and left ventricular enlargement, left atrial enlargement, the degree of prominence of the main pulmonary artery, the size of the hilar shadows, the degree of engorgement of the pulmonary vascular tree, the presence or absence of the "infundibulum sign," the position of the main and left pulmonary arteries, the size of the aorta, and the relative size of the peripheral pulmonary veins, and an opinion was rendered concerning the presence of a "typical" appearance. From the charts, information was obtained concerning the electrocardiographic findings, the size of the ductus, and the presence of cyanosis.

It was at once realized that there was a difference in the estimation of heart size and contour between different observers and that therefore it would be desirable to have independent evaluation done by the two participating radiologists, both of whom had experience in the diagnosis of congenital heart disease, obtained in teaching centers in different parts of the country. The gradation of changes manifested in the roentgenograms was recorded in a system of pluses: 1+ indicating slight degree of change, 2+ moderate change, and 3+ marked change. Where there was disagreement between the individual readings, this difference was recorded. In those cases where disagreement extended only to the degree of change, an average of the two readings was listed.

It should be pointed out that the size of the ductus was based on estimations of the

surgeon at the time of operation and is therefore by no means exact. There is also individual variation in the electrocardiograph reports, since these were read by different physicians over the years covered by this study.

Of the 100 patients studied, 28 were males and 72 females. The female to male ratio of 2.5:1 compares favorably with that of Donovan *et al.*, who reported a ratio of 2:1.

The patients studied ranged in age from five and one-half months to thirty-six years, with a mean age of six and one-half years. Sixty-four per cent of the patients in this group were below the age of ten years. This is somewhat in contrast with the group of Donovan *et al.*, in which the age range was from one year to thirty-six years but the mean age was eleven years.

Ductus diameters were given in all but 3 cases, and lengths in all but 10 cases. Diameters ranged from 2 to 20 mm., and the lengths from 3 to 25 mm.

#### RESULTS

*Variation in Individual Interpretation:* In analyzing the differences in interpretation between the authors' observations, it was found that the great majority occurred in detecting minimal findings, particularly in determination of the presence of slight change as opposed to the normal state. When the signs were moderate or marked in degree, excellent agreement was the rule. The highest incidence of difference occurred in determining the state the hilar shadows and pulmonary vascular tree. Here the disagreement reached an average of 24 per cent. A similar range of disagreement occurred in the grading of prominence of the undivided portion of the pulmonary artery. This determination is complicated by the normal prominence of the artery in young people.

Differences in estimation of cardiac and chamber enlargement fell into a like range, with an average of 15 per cent. The differences in interpretation of the "infundibulum sign," elevation of the main

and left pulmonary arteries, and size of the aorta, were 14 per cent, 13 per cent, and 11 per cent, respectively. It thus appears that one of the major difficulties lies in the determination of alterations from normal of the cardiac contour and the pulmonary vessels. Once the presence of these changes has been definitely established, it may become possible to make the diagnosis of patent ductus arteriosus. This variation in the individual interpretation of chamber or vessel enlargement has not been emphasized in previous studies.

*Cardiac Enlargement:* Cardiac enlargement was present in 73 per cent of the cases. In more than half of these the enlargement was either moderate or marked in degree. The common impression that the heart in patent ductus is usually normal in size was not borne out in this series. The figures are in excellent agreement with those of Donovan *et al.*, 76 of whose patients showed cardiac enlargement.

*Chamber Enlargement:* The commonly accepted roentgen criteria of chamber enlargement were utilized in this series. Left ventricular and left atrial enlargement occurred in almost identical incidence, 68 and 67 per cent, respectively. Donovan *et al.* reported a similar though slightly higher incidence of left atrial enlargement, namely, 71 per cent. The degree of left atrial enlargement was slight or moderate in all but 10 per cent of the cases which showed such enlargement in the present series. Enlargement of this chamber has been an extremely helpful sign in the diagnosis of patent ductus.

Forty-two per cent of the patients showed roentgen evidence of right ventricular enlargement. This is somewhat at variance with the usual concepts of the hemodynamics of patent ductus arteriosus. Experience at this institution, however, has been similar to that of Neuhauser and Wittenborg (7), in that there is an increasing awareness of the existence of a type of patent ductus arteriosus with atypical clinical signs. Cases of this type are usually confused with other congenital

heart lesions. These patients have high right ventricular pressure with movement of the blood through the shunt in varying directions, or with equalized ventricular pressures. The pulmonary hypertension is either the result of an unusually large ductus, with the high aortic pressure being

TABLE I: ELECTROCARDIOGRAPHIC FINDINGS IN 100 CASES OF PATENT DUCTUS ARTERIOSUS

	Number	%
No electrocardiogram	8	7.6
Normal	49	48.0
Left ventricular hypertrophy	32	30.7
Right ventricular hypertrophy	7	6.7
Interventricular block	4	3.8
High voltage QRS	1	0.9
Borderline	2	1.9
Atrioventricular block	1	0.9
Total	104	100.5

Three cases had ventricular hypertrophy plus interventricular block and are included in both categories.

One case had both right and left ventricular hypertrophy and are included in both categories.

transmitted to the pulmonary artery or the presence of a spasm or narrowing of the smaller pulmonary vessels. Neuhauser and Wittenborg suggest that a neurocirculatory reflex system raises the pulmonary pressure in these cases to a relative degree of hypertension. If this did not occur, bleeding into the pulmonary vascular bed would lead to a state of shock.

The patients with high right ventricular pressure have right ventricular enlargement as well. It is this group with atypical ductus arteriosus which may show cyanosis. Seven of the 100 patients in the present series had some degree of cyanosis. In 6 cases this was minimal and of a varying degree, usually associated with exertion or coughing. The other patient, aged five and one-half months, had persistent cyanosis and a large ductus (Fig. 1).

*Electrocardiographic Findings:* It is of interest at this point to compare the roentgen diagnosis of chamber enlargement with the electrocardiographic findings. The latter are summarized in Table I. Three cases showed ventricular hypertrophy plus interventricular block and were listed under both categories. One patient had

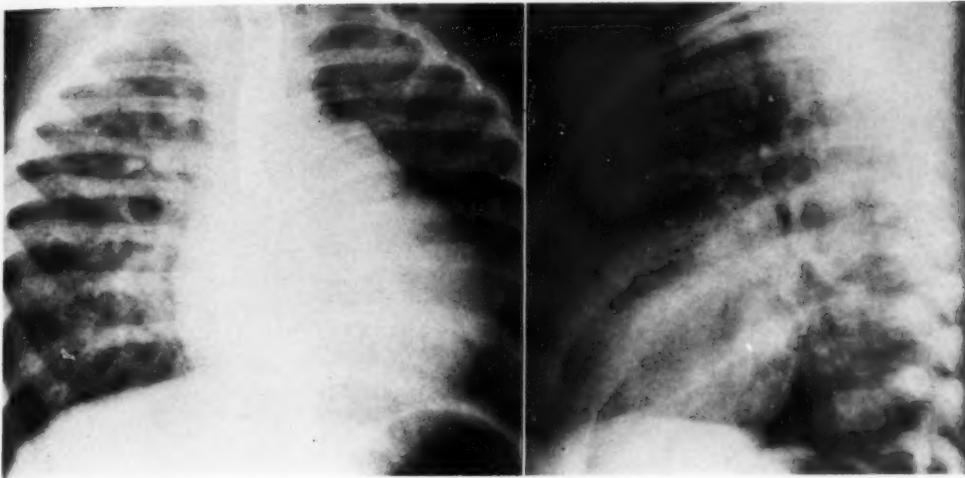


Fig. 1. Roentgenograms of chest of cyanotic child of five and a half months. Right and left ventricular enlargement is evident. The pulmonary artery and its branches are also increased in size. Ductus measured 9 mm. in diameter.

both right and left ventricular hypertrophy and is likewise listed twice. Apparently the roentgenogram is a more sensitive indicator of the cardiac changes in patent ductus arteriosus: 50 per cent of the electrocardiograms were abnormal, whereas x-rays showed 73 per cent of the hearts enlarged; 30.7 per cent of the electrocardiograms showed left ventricular enlargement, as opposed to 68 per cent of the roentgen studies; 6.7 per cent of the electrocardiograms showed right ventricular enlargement, as compared to 42 per cent of the films. There was little doubt that a positive electrocardiographic report is of great aid in diagnosis of patent ductus, but this is obtained only in about one-half of the cases. With the increasing experience of electrocardiographers in congenital heart disease, there have been changes in diagnostic criteria which may not be reflected in this series.

*Pulmonary Outflow Tract Enlargement:* Enlargement of the pulmonary outflow tract, including the main pulmonary artery, the right and left pulmonary arteries, and the peripheral pulmonary vasculature, are fairly constant findings. The pulmonary artery itself was noted to be enlarged in 68 per cent of the cases, and the

pulmonary vessels were engorged in 59 per cent, as opposed to 82 per cent and 70 per cent, respectively, in the group reported by Donovan *et al.* Part of this discrepancy might be explained by the age difference between the two groups, for these signs become more reliable in older patients. The mean age for Donovan's cases was eleven years, whereas the mean age for the present series was only six and one-half years.

*Venous Engorgement:* We have found enlargement of the pulmonary veins to be a fairly reliable indicator of the presence of a left-to-right intracardiac shunt. The pulmonary veins can best be seen in the postero-anterior projection adjacent to the right heart border and in the left anterior oblique projection superimposed upon the cardiac shadow below the pulmonary artery. In other conditions, such as pulmonary stenosis and mitral valvular disease, in which there are also frequently large pulmonary arteries, the pulmonary veins usually appear normal or small in caliber (9).

*The "Infundibulum Sign":* The "infundibulum sign" has not proved to be a very consistent indicator of patent ductus arteriosus. Its presence was detected in

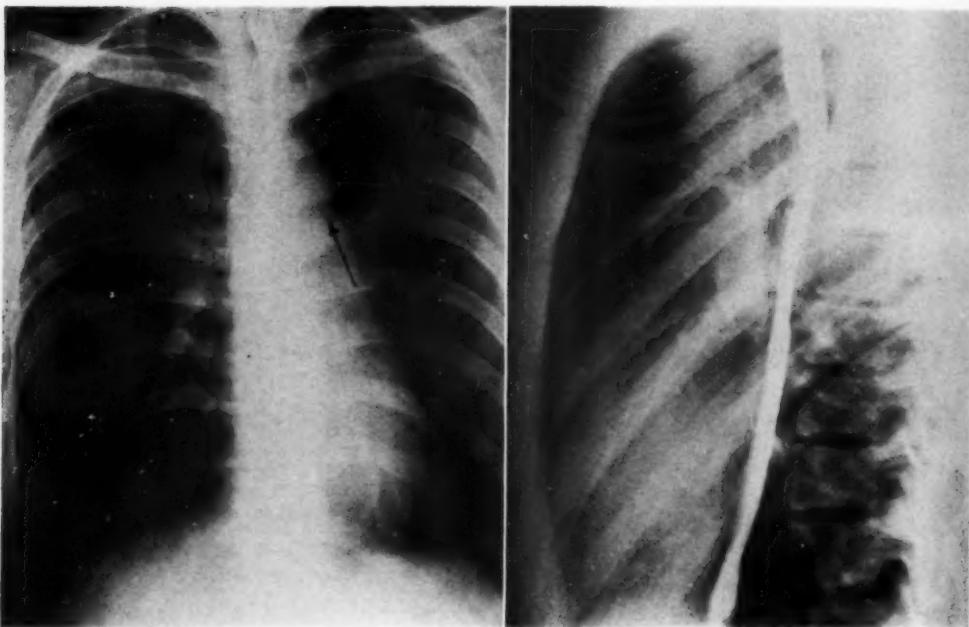


Fig. 2. Roentgenograms of chest of twenty-six-year-old male with ductus 10 mm. in diameter, demonstrating "infundibulum sign" and "atypical" cardiac configuration.

only 25 per cent of the cases in this series. The area of its possible occurrence was frequently obscured by the dilated pulmonary artery. Its reliability is further questioned in view of the presence of similar configurations of the aorta in patients without congenital heart disease.

Of 100 additional patients without clinical evidence of congenital heart disease, between the ages of two and thirty-five years, who were examined for the infundibulum sign, only 5 showed shadows which could be thus interpreted. At best, this sign is only confirmatory (Fig. 2).

*Elevation of the Left and Main Pulmonary Arteries and Increased Size of the Aorta:* Elevation of the left and main pulmonary arteries and increased size of the aorta were found in only 5 and 11 per cent of the cases, respectively, and are not felt to be either reliable or significant signs. The obscuration of the proximal part of the left pulmonary artery by the dilated main pulmonary artery may be a factor in producing the apparent elevation of the left main pulmonary artery.

*Typical Appearance:* In studying this group of films an attempt was made to establish criteria for a "typical" appearance of the heart and pulmonary vasculature in patent ductus arteriosus. Classically, the heart is moderately enlarged, with slight to moderate enlargement of the left atrium and left ventricle. The undivided portion of the pulmonary artery and the hilar shadows are slightly increased in prominence, and there is slight to moderate pulmonary vascular engorgement (Fig. 3). Utilizing these criteria, the incidence of the "typical" appearance was plotted against the age of the patients.

It was found that the older patient is more likely to present the "typical" appearance. In the group below the age of ten, only 31 per cent of the hearts were "typical," while in patients from ten to thirty-six years, 58 per cent were "typical." Of 17 children from five and one-half months to three years, only 4 (24 per cent) were considered to have a "typical" picture. It is in this early age group, also, that interpretation of the clinical findings

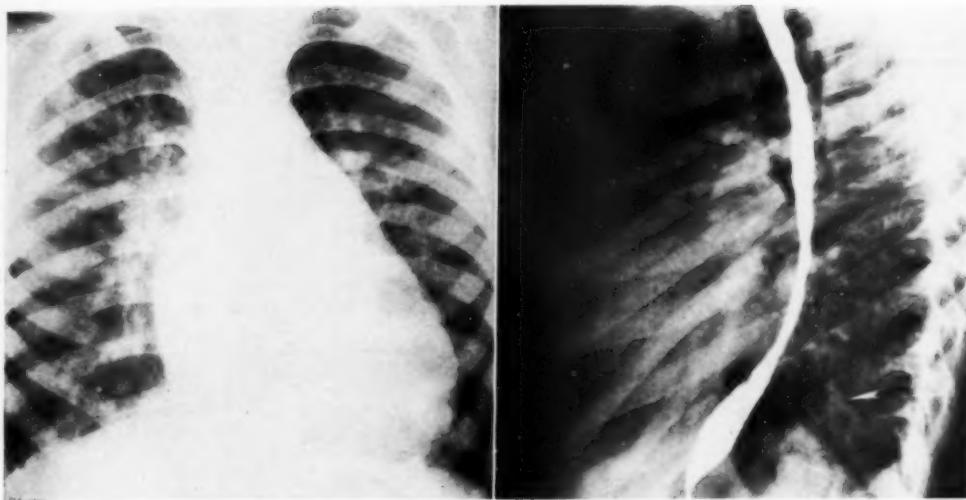


Fig. 3. Roentgenograms of chest of four-year-old child with ductus 8 mm. in diameter, demonstrating "typical" appearance of heart and pulmonary vasculature.

is most difficult, since the characteristic diastolic systolic murmur may be absent (Fig. 2).

*Size of Ductus:* It appears that, as the patient grows older, the diameter of the ductus increases concomitantly with the increase in body size. The average diameter in the various age groups was as follows:

Age	Diameter
0-5	6.5 mm.
5-10	7.4 mm.
10-15	5.7 mm.
15-20	10.6 mm.
20-25	10.0 mm.
25-30	17.8 mm.

In Table II the ductus diameter has been correlated with the degree of abnormality of the heart and pulmonary vessels. It is apparent, as one would expect, that the diameter of the ductus is roughly proportional to the heart size, prominence of the undivided portion of the pulmonary artery, increase in hilar shadows, and increase in pulmonary vascularity. This relationship can be better demonstrated if the correlation between ductus size and degree of abnormality of the cardio-

Table II: CORRELATION OF DUCTUS DIAMETER WITH ROENTGEN FINDINGS ON 100 CASES OF PATENT DUCTUS ARTERIOSUS

Ductus (mm.)	Cardiac Enlargement			
	0	1+	2+	3+
2-5	1	7	1	
5-7	8	7	10	2
7-11	4	9	13	13
11-13		1	2	3
13-15				
15-20			4	
Prominence of Undivided Portion of Pulmonary Artery				
2-5	2	6	1	
5-7	5	14	6	
7-11	4	16	11	3
11-13	2	2		
13-15				
15-20		2	2	
Increased Hilar Shadows				
2-5	3	5		
5-7	5	9	5	2
7-11	3	16	11	7
11-13	1	4		
13-15				
15-20		2	2	
Increased Pulmonary Vascularity				
2-5	4	5		
5-7	7	10	3	2
7-11	1	12	12	6
11-13	1	1	2	1
13-15				
15-20			4	

vascular shadows is considered in relation to the age of the patient. One would expect that a ductus of 5 mm. diameter

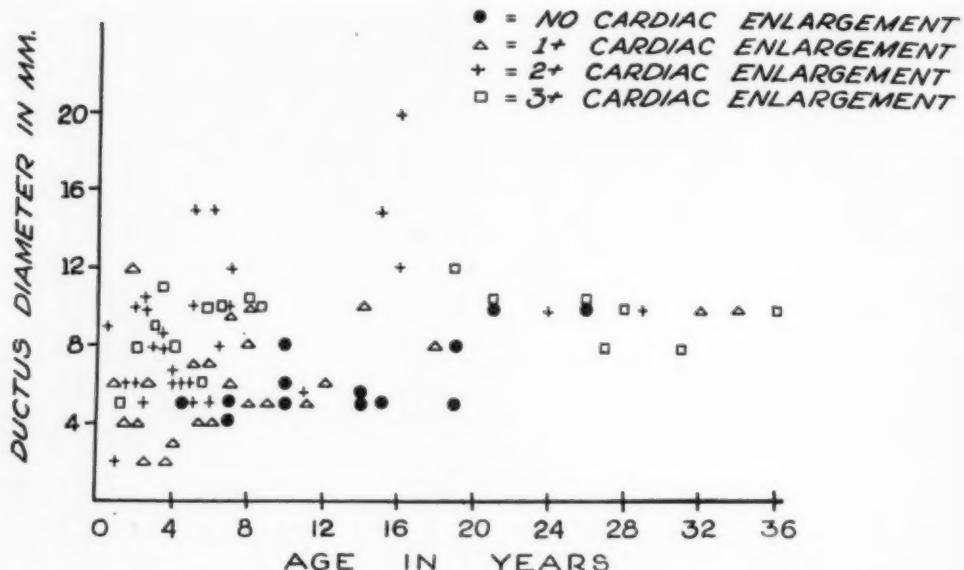


Chart I. Correlation of age, ductus diameter, and heart size in 100 cases of patent ductus arteriosus.

would have a more profound adverse effect in an infant than in an adult.

To demonstrate the validity of this assumption, the degree of cardiac enlargement of each case was plotted against that patient's age and ductus diameter (Chart I). From these data a histogram was prepared for each degree of cardiac enlargement, utilizing the mathematical averages of the ductus diameters falling within the ages of 0 to four years, of four to eight years, etc. (Chart II). Moderate and marked cardiac enlargement were treated as a single group.

The histogram graphically demonstrates the increase in ductus diameter with increase in age, and also a good correlation between ductus size and cardiac enlargement.

It is worthy of note that below the age of four years there are no cases without cardiac enlargement, whereas in the groups from four to twenty years most of the hearts with ductus diameters of the same magnitude as those of the younger group were of normal size. It is necessary, therefore, to realize that in a young patient a ductus of small diameter will have

greater physiologic effects than one of the same size in an older person. In later life, a larger ductus is required to produce the same degree of enlargement as in a younger patient. One can then predict in an approximate manner the size of the ductus from the profundity of the physiologic changes apparent on the plain films.

Chart II also demonstrates that after the age of twenty years an average ductus diameter of 10 mm. is fairly constant, and that all degrees of cardiac enlargement fall roughly about this level.

Two unusual roentgen findings were encountered in this group of patients. One, a thirty-two year old male, showed calcification in the patent ductus. The other, a three and one-half year old female, demonstrated an unusual impression on the barium-filled esophagus immediately below the aortic impression. This was produced by a large patent ductus (Fig. 4).

#### SUMMARY AND CONCLUSIONS

The roentgenograms of 100 cases of patent ductus arteriosus were studied and their salient features tabulated.

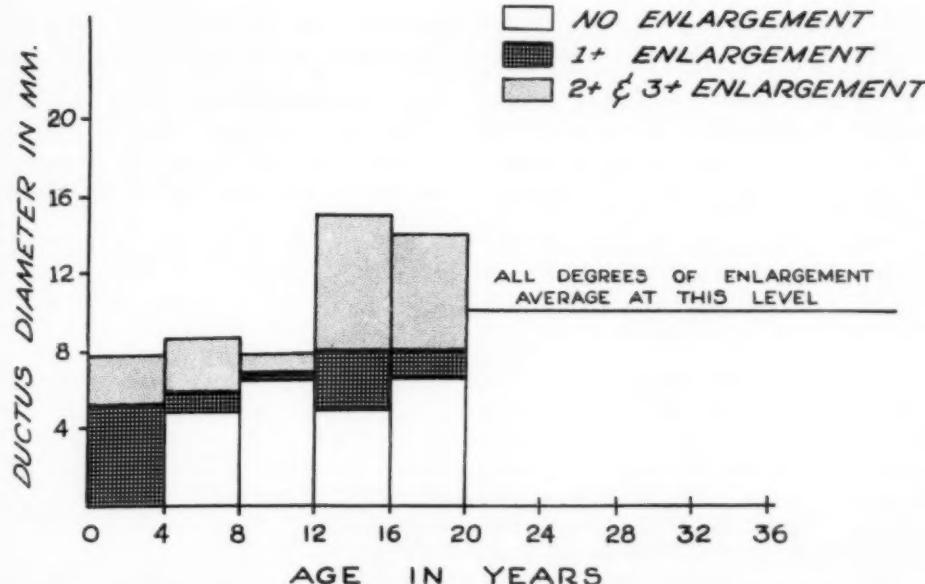


Chart II. Histogram of correlation of age, ductus diameter, and heart size in 100 cases of patent ductus arteriosus.

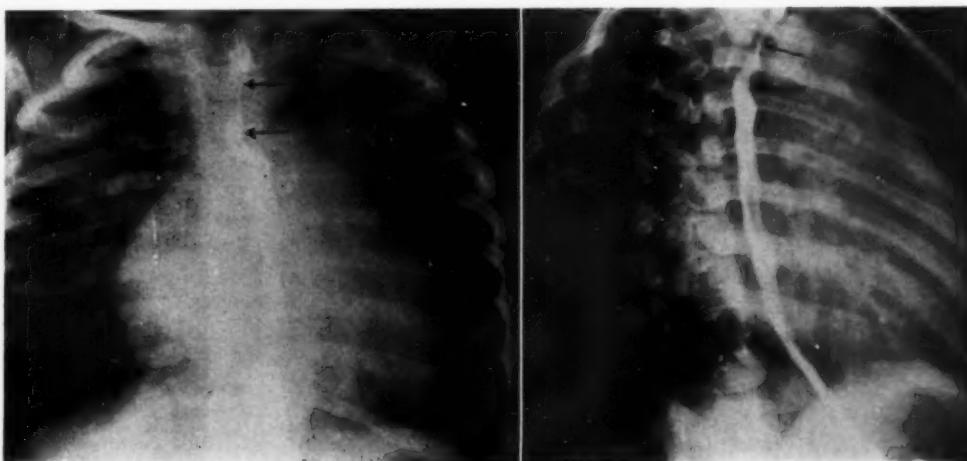


Fig. 4. Roentgenograms of chest of child three and a half years old, demonstrating unusual impression on barium-filled esophagus immediately below aortic impression. This impression was produced by a large patent ductus measuring 11 mm. in diameter.

Cardiac enlargement was present in 73 per cent of the cases. The chambers most frequently enlarged were the left ventricle (68 per cent) and the left auricle (67 per cent). Enlargement of the left auricle, when present, was found to be of some value in differentiating patent ductus arteriosus from other congenital cardiac

abnormalities. Forty-two per cent of the patients showed roentgen evidence of right ventricular enlargement. This was observed in those patients with presumed pulmonary hypertension as a result of a large ductus or constriction of the peripheral branches of the pulmonary arteries. One patient with a large right ventricle

had persistent cyanosis from birth and a large ductus. Seven patients had cyanosis of varying degrees.

The authors' individual interpretations of degree of abnormality of the heart and major vessels as shown roentgenographically differed considerably. This was particularly true of the estimation of the size of the hilar shadows and pulmonary vascularity, where the disagreement averaged 24 per cent. Differences in estimation of cardiac and chamber enlargement averaged 15 per cent.

Fifty per cent of the electrocardiograms were interpreted as being abnormal. Thirty per cent showed left ventricular hypertrophy, 7 per cent right ventricular hypertrophy, and 4 per cent interventricular blocks. Cardiac and chamber enlargement was observed on the roentgenograms in a larger number of patients than the electrocardiogram would indicate.

The main pulmonary artery was enlarged in 68 per cent of the cases and its branches in 59 per cent. As would be expected, the pulmonary veins were engorged in most cases in which the pulmonary arteries were enlarged.

The "infundibulum sign" was found to be unreliable in our experience. It was detected in only 25 per cent of the cases, and similar alterations of the aortic shadow were found in an independent survey of normal chests in the same age groups.

The cardiac shadow was considered to have an appearance "typical" of patent ductus arteriosus in 41 per cent of the cases. In the age group from five and one-half months to three years, only 24 per cent were considered typical, whereas 58 per cent between the ages of ten and thirty-six appeared "typical."

The size of the ductus was found to correlate well with the degree of cardiac en-

largement and pulmonary vascularity in the various age groups. Below the age of four years all patients had cardiac enlargement. In the older age groups a ductus of greater diameter was required to produce the same relative degree of cardiac and vascular enlargement than in the younger children.

University of California Medical Center  
San Francisco 22, Calif.

#### REFERENCES<sup>2</sup>

1. DONOVAN, M. S., NEUHAUSER, E. B. D., AND SOSMAN, M. C.: The Roentgen Signs of Patent Ductus Arteriosus. A Summary of 50 Surgically Proven Cases. Am. J. Roentgenol. **50**: 293-305, September 1943.
  2. EPPINGER, E. C., AND BURWELL, C. S.: The Mechanical Effects of Patent Ductus Arteriosus on the Heart and Their Relation to X-Ray Signs. J.A.M.A. **115**: 1262-1264, Oct. 12, 1940.
  3. GRIER, G. W.: The Diagnosis of Congenital Heart Lesions in Children. Am. J. Roentgenol. **49**: 366-392, March 1943.
  4. JÖNSSON, G., AND SALTMAN, G.-F.: Infundibulum of Patent Ductus Arteriosus—A Diagnostic Sign In Conventional Roentgenograms. Acta radiol. **38**: 8-16, July 1952.
  5. LYNXWILER, C. P., AND WELLS, C. R. E.: Patent Ductus Arteriosus—A Report of 180 Operations. South. M. J. **43**: 61-67, January 1950.
  6. NEUHAUSER, E. B. D.: Medical Progress. Recent Advances in the Roentgenographic Diagnosis of Congenital Malformations of the Heart and Great Vessels. New England J. Med. **242**: 753-758, May 11, 1950.
  7. NEUHAUSER, E. B. D., AND WITTENBORG, M. H.: Pediatric Radiology. New England J. Med. **249**: 62-68, July 9, 1953.
  8. NICHOL, A. D., AND BRANNAN, D. D.: The Differentiation of Patent Ductus Arteriosus and Atrial Septal Defect. Am. J. Roentgenol. **58**: 697-707, December 1947.
  9. STEINBACH, H. L., KEATS, T. E., AND SHELINE, G. E.: The Roentgen Appearance of the Pulmonary Veins in Heart Disease. To be published in Radiology.
  10. STEINBERG, M. F., GRISHMAN, A., AND SUSSMAN, M. L.: Angiocardiography in Congenital Heart Disease. III. Patent Ductus Arteriosus. Am. J. Roentgenol. **50**: 306-315, September 1943.
  11. TAUSSIG, H. B.: Congenital Malformations of the Heart. New York, The Commonwealth Fund, 1947.
- <sup>2</sup> A further paper on patent ductus arteriosus, appearing after the present contribution was submitted for publication, is by MARGULIS, A. R., FIGLEY, M. M., AND STERN, A. M.: Unusual Roentgen Manifestations of Patent Ductus Arteriosus. Radiology **63**: 334-345, September 1954.

## SUMARIO

**Conducto Arterioso Permeable. Justipreciación Analítica de Sus Signos Roentgenológicos**

Después de estudiar las radiografías de 100 casos de conducto arterioso permeable, se tabularon sus características salientes.

Existía hipertrofia cardíaca en 72 por ciento de los casos. Las cavidades hipertrofiadas más frecuentemente fueron el ventrículo izquierdo (68 por ciento) y la aurícula izquierda (67 por ciento). Cuando existía, la hipertrofia de la aurícula izquierda resultó ser de algún valor para diferenciar el conducto arterioso permeable de otras anomalías cardíacas congénitas. Cuarenta y dos por ciento de los enfermos revelaron signos roentgenológicos de hipertrofia del ventrículo derecho. Esto fué observado en los enfermos que tenían hipertensión pulmonar a consecuencia de un conducto agrandado o de constricción de las ramas periféricas de las arterias pulmonares. Un enfermo que tenía un ventrículo derecho hipertrofiado había padecido de cianosis persistente desde el nacimiento y de hipertrofia del conducto. Siete pacientes tenían cianosis más o menos intensa.

Discreparon considerablemente las interpretaciones dadas por los dos autores a la gravedad de la anomalía del corazón y los vasos mayores, según se observó radiográficamente. Esto rezó en particular con el cálculo del tamaño de las sombras hilares y la vascularidad pulmonar, en cuyo punto el desacuerdo promedió 24 por ciento. Las diferencias en el cálculo de la hipertrofia del corazón y de las distintas cavidades promedió 15 por ciento.

Cincuenta por ciento de los electrocar-

diogramas fueron interpretados como anormales. Observóse radiográficamente hipertrofia del corazón y de las cavidades en un número mayor de enfermos que el indicado por los electrocardiogramas.

La principal arteria pulmonar mostró hipertrofia en 68 por ciento de los casos y sus ramas mostraron otro tanto en 59 por ciento. Como era de esperar, las venas pulmonares estaban congestionadas en la mayor parte de los casos en que estaban hipertrofiadas las arterias pulmonares.

El "signo infundibular" se mostró inconsistente. No se descubrió más que en 25 por ciento de los casos, y se notaron alteraciones semejantes de la sombra aórtica en una encuesta separada de tóraces normales en grupos de edad idéntica.

Se consideró que la sombra cardíaca tenía aspecto "típico" de conducto arterioso permeable en 41 por ciento de los casos. En el grupo de cinco meses y medio a tres años de edad, sólo 24 por ciento fueron considerados típicos, en tanto que parecían serlo 58 por ciento de los sujetos de 10 a 36 años de edad.

El tamaño del conducto, según se observó, correlacionó bien con el índice de hipertrofia cardíaca y vascularidad pulmonar en los varios grupos de edad. Por debajo de la edad de cuatro años, todos los enfermos tenían hipertrofia cardíaca. En los grupos de mayor edad, se necesitaba un conducto de diámetro mayor para producir la misma clase de hipertrofia cardíaca y vascular observada en los niños más jóvenes.

## Syndrome Associated with Mucocele of the Sphenoid Sinus

Report of Two Cases and Their Radiographic Findings<sup>1</sup>

HOWARD M. SIMON, JR., M.D.,<sup>2</sup> and FRED R. TINGWALD, M.D.<sup>3</sup>

THE DIAGNOSIS of mucocele of the sphenoid sinus is usually made at autopsy or at surgery, when a transdural procedure often leads to a fatal meningitis. In the majority of reported cases, radiologic examination was not carried out; in those in which such examination was performed, it was inadequate or the findings were not appreciated. Until recent French publications (1-3), there were few, if any, detailed radiographic descriptions of sphenoid mucocele in the literature.

In 1946, Linthicum and his associates (4) estimated that not more than 25 cases of mucocele of the sphenoid sinus had been reported, and they described the autopsy findings in an additional case. A review of the literature since their report reveals 3 cases (1, 5, 6) and possibly a fourth (7). Two additional cases, with radiographic findings follow.

### CASE SUMMARIES

CASE I: A 58-year-old white woman was first seen on July 23, 1947, with a history of decreasing vision and floating spots in the left eye. The vision in the left eye was noted to fluctuate spontaneously, while the right eye was affected to a milder degree. For a year and a half the patient had experienced an almost constant headache mainly confined about the left eye. The sense of smell was not affected. On admission vision was O.D. 3/12, O.S. 3/60, correctable to O.D. 3/5, O.S. 3/12. Eye diagnosis was optic neuritis with retinitis on the left. Complete neurologic examination showed no abnormalities except for vision. Roentgen studies of the skull were reported as follows: "Anteroposterior diameter of the sella turcica is 16 mm., and the vertical diameter is 12 mm.; the floor of the sella is thin; and the posterior clinoids are thin and appear tilted upward." The x-ray diagnosis was "changes in sella turcica consistent with pituitary adenoma."

The patient was next seen one year later. Vision in the left eye had continued to fluctuate from none at all to recognition of hand movements. Frequent

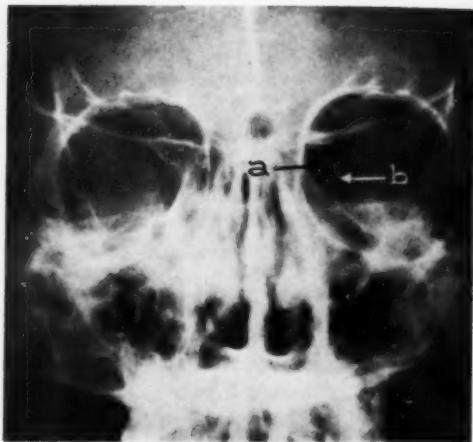


Fig. 1. Case I. Enlargement of the superior orbital fissure on the left (*a*), with irregularity of its medial and inferior margins; marked lateral displacement of the lamina papyracea (*b*).

left-sided headaches were still present. Eye diagnosis was "secondary optic atrophy, left."

The third visit was on Dec. 22, 1950, three and a half years after initial examination. One year before this visit the patient had noted the onset of left nasal obstruction with mucopurulent nasal discharge and a loss of the sense of smell. On Oct. 29, 1950, she had undergone surgery for the nasal obstruction and had been told that the growth in her nose was only partially removed. At that time about an ounce of brown mucoid fluid was obtained, which was reported as "degenerated tissue" by the local pathologist. Since the operation the patient had experienced two episodes of swelling and protrusion of the left eye and there had been a constant bloodtinged left nasal discharge. Examination now showed complete anosmia, total blindness on the left, with exophthalmos, and a mass obliterating the left choana.

Biopsy of the left intranasal tumor was attempted on Dec. 27, 1950, shortly after the patient's third visit. A large cavity was entered, involving the sphenoid and left posterior ethmoidal region. The nasal wall of this cavity was completely removed and the cavity was packed with Lipiodol gauze.

The patient was last seen on Sept. 8, 1952, ap-

<sup>1</sup> From the Cleveland Clinic and the Frank E. Bunts Educational Institute, Cleveland, Ohio. Presented at the Fortieth Annual Meeting of the Radiological Society of North America, Los Angeles, Calif., Dec. 5-10, 1954.

<sup>2</sup> Fellow in the Department of Radiology, Cleveland Clinic.

<sup>3</sup> Department of Otolaryngology, Cleveland Clinic.

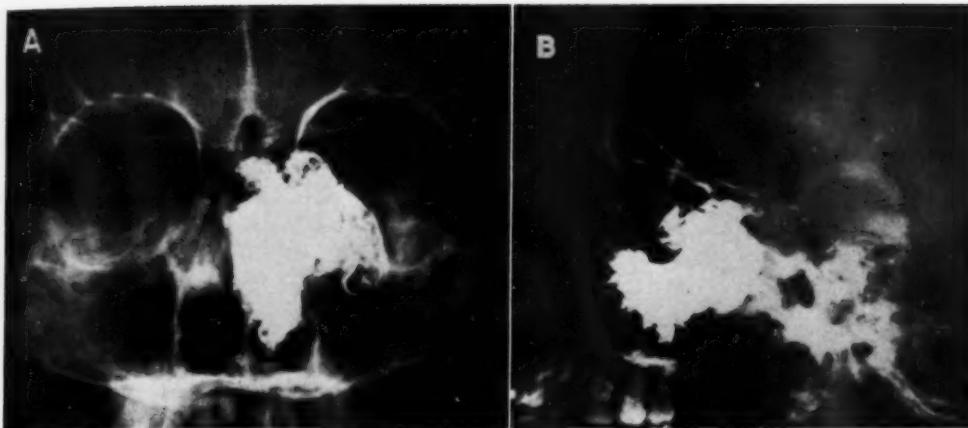


Fig. 2. Case I. Views with Lipiodol-soaked gauze packed into the cavity of the mucocele, showing its huge size. The thin and partially eroded anterior half of the sellar floor can be noted in B.

proximately five years after the initial examination. At this time the drainage area was wide open and she had been completely relieved of her nasal symptoms and headaches. No specific note concerning sense of smell was made. The blindness in the left eye had persisted.

**CASE II:** A 47-year-old Negro man was originally seen on Dec. 1, 1952, with a history of left frontal headaches, bilateral nasal obstruction, and anterior and posterior nasal discharge of clear to yellow mucus, all of which had been present intermittently for approximately twenty years. In 1949, a left intranasal operation, type unknown, had been performed. Headache about the left forehead, eye, and temple had recurred about three weeks prior to admission and on this occasion had been accompanied by failing vision in the left eye. Findings on admission were: congested, edematous nasal mucosa, worse on the left; dark sinus transillumination throughout; vision O.D. 6/7+, O.S. 6/9, correctable to O.D. 6/5-3, O.S. 6/7-2. Sinus roentgenography (no sphenoid views) showed increased density throughout. Laboratory findings were all normal including urinalysis, blood count, blood sugar, serologic tests, and spinal fluid examinations.

On Dec. 11, 1952, ten days after admission, vision in the left eye had deteriorated to 6/21. On Dec. 15, it had improved to 6/12. A left antral irrigation yielded 5 c.c. of yellow mucopus.

On Dec. 29, four weeks after admission, vision had further improved to 6/9 on the left, and headache was relieved. A left antral irrigation returned 1 c.c. of clear mucus.

The next visit was on Feb. 23, 1953, two and a half months after admission, at which time the patient stated that, following the "flu" during the preceding month, his headache had returned and vision had again failed. It was now found to be O.D. 6/6-1,

O.S. 6/60. Again there was a spontaneous remission.

The patient was next seen on June 1, 1953, six months after his first admission, complaining of pressure and pain about the left eye and a total loss of vision on that side. Roentgen examination of the sella turcica at this time showed erosion and destruction of the floor. A tentative diagnosis of pituitary neoplasm was made.

On June 17, 1953, two weeks later, an encephalogram revealed no additional abnormalities. Following this, a right frontal craniotomy was done and a left sphenoid mucocele demonstrated. The mucocele was decompressed, and the dura was closed, with no attempt at removal. The headache was relieved but vision did not improve. Additional roentgenographic studies were made at this time. They defined the limits of the mucocele confirmed at subsequent surgery.

The patient was again seen on July 29, about a month and a half after craniotomy, with recurrence of left periorbital headache. Also, for the first time he complained of loss of the sense of smell.

Two days later, on July 31, a repeat nasal examination was done, showing the anterior wall of the left sphenoid to be 1.5 cm. closer to the anterior nasal spine than that of the right. A left sphenoid puncture was done, with removal of about 10 c.c. of chocolate-colored fluid. Headache was immediately relieved.

On Aug. 5, 1953, seven months following the original admission, a left external spheno-ethmoid procedure was done. Just 0.5 cm. posterior to the anterior ethmoidal vessel a dehiscence was found in the ethmoidal capsule, with protrusion of an encapsulated mass. The capsule was opened medially, a cystic cavity was entered, and the contents were aspirated. On inspection the cavity was found to occupy the left sphenoid and posterior ethmoid areas. The nasal wall of the cystic capsule was re-



Fig. 3. Case II. Left optic foramen, exaggerated view, showing loss of entire floor of optic canal. *a.* Margin of destroyed lamina papyracea and lateral wall of sphenoid body. *b.* Margin of enlarged and distorted superior orbital fissure.

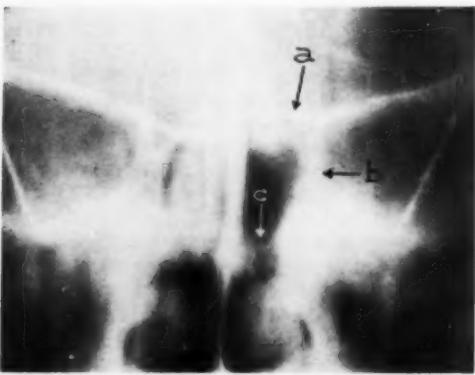


Fig. 4. Case II. Anteroposterior laminagram at 13 cm. *a.* Destruction of jugum sphenoidale (superior surface of sphenoid body) medially and elevation laterally. *b.* Irregularity and destruction of lateral wall of sphenoid sinus and absence of lamina papyracea. Lateral wall 4 mm. farther from mid-line on left than on right. *c.* Depression of floor of left sphenoid sinus (not fully appreciated at this level).

moved, including the anterior sphenoidal wall, leaving an intranasal opening estimated to be  $2 \times 2$  cm. The cavity was packed with vaseline gauze, and the skin incision was closed. All sutures and packing were removed on the fifth postoperative day. The following day the patient was discharged after the cavity had been filled with Lipiodol and roentgenograms had been obtained.

The patient was last seen on Sept. 1, 1953, eight

months after admission, at which time the headache was relieved, vision O.S. was light perception only, and anosmia was still present. Healing was complete, and the drainage area remained widely patent.

#### DISCUSSION

Investigations have led us to conclude that a mucocele of the sphenoid sinus

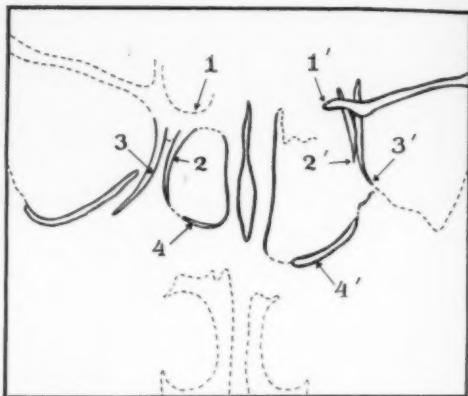


Fig. 5. Case II. Composite drawing of several anteroposterior laminagrams. 1. Normal jugum sphenoidale on right. 1'. Absence of medial and elevated lateral portions on left. 2. Lateral wall of right sphenoid 17 mm. from mid-line. 2'. Fragment of left lateral wall at least 21 mm. from mid-line. 3. Right lamina papyracea. 3'. Lamina papyracea not identifiable on left. 4. Floor of right sphenoid sinus. 4'. Depressed floor of left sphenoid.

produces a definite syndrome with associated radiographic evidence sufficient for clinical diagnosis. The syndrome produced by lesions about the orbital inlet which cause painful headaches and ophthalmologic abnormalities has long been termed the "sphenoid fissure syndrome." Holt and de Röth (8), contrary to their findings in the American literature, discovered that reports of this syndrome were not scarce in the French literature and proposed the term "orbital apex and sphenoid fissure syndrome," since the optic canal is also involved in some cases. Tassman (9) suggests the term "sphenoid fissure-optic canal (S-O) syndrome with complete ophthalmoplegia," because he considers the syndrome incomplete when the optic nerve or other structures are spared. Sphenoid mucocele certainly should be considered as a possible cause of this syndrome, inasmuch as the optic nerve

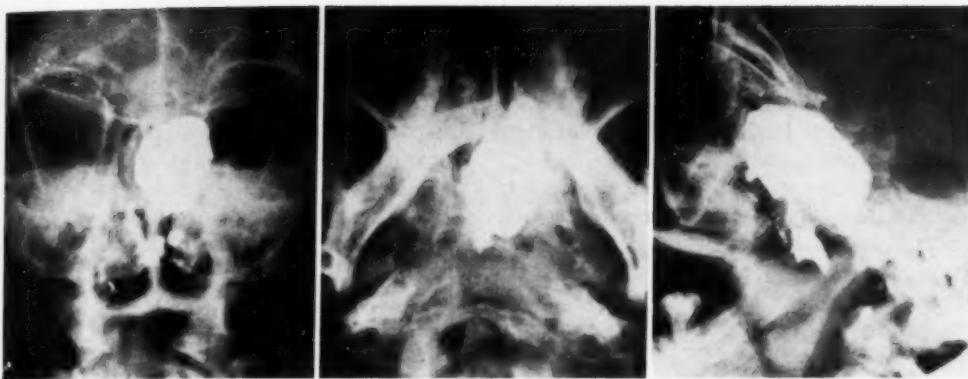


Fig. 6. Case II. Postoperative views showing the cavity filled with 18 c.c. of Lipiodol. Destruction of floor of the sella not well reproduced here, but intact anterior clinoids can be noted.

is almost always involved and other manifestations are similar. Furthermore, partial or complete ophthalmoplegia can result, depending on the duration of the condition (10). Therefore, the simple term "orbital inlet syndrome" would appear to describe adequately the various combinations of signs and symptoms that may occur as a result of lesions in this region.

Mucocele has been well defined by others and its incidence and occurrence in other sinuses have been reported (11, 12). There is rather convincing evidence that it should be considered of spheno-ethmoidal origin (13). However, it has not been determined whether a particular cellular arrangement is necessary. It can only be speculated that the mucocele primarily develops in the sphenoid sinus and later erodes into the normally situated posterior ethmoid cells or, in the presence of an anatomic variant, develops in an intermediate or prolonged cell and spreads in all directions simultaneously.

The etiology has been ascribed to several factors (12). Suffice it to state that the ostium or lumen of the duct is occluded and the normal drainage from within the sinus is blocked. With the prevention of the escape of normal secretions, there is a gradual increase in pressure within the sinus, with accompanying expansion that is often asymmetric. There is progressive pressure necrosis of the osseous struc-

tures, with subsequent extension through the paths of least resistance, namely, the extradural spaces, the superior orbital fissure, and the optic canal. Finally, this pressure is applied to the adjacent nerves, to the blood vessels, and even to the brain substance.

Before discussing the clinical findings, we will briefly consider two factors that lead to inaccurate diagnoses in this region: the structural weaknesses of the orbital inlet and the peculiarities of certain lesions. The reader is referred to other articles for excellent descriptions of the normal anatomy and the variations of the optic canals (14) and superior orbital fissures (15, 16).

Points of weak resistance (17) which may show the earliest changes are formed by the lesser wings, the anterior clinoids, and the superior orbital fissures, whose margins are free. These structures are depressed by pressure from the anterior fossa, whereas pressure arising from the temporal fossa or orbit raises them. This displacement is significant only for the lesser wing and its free clinoid extremity. However, the sphenocephalic (superior orbital) fissure is subject to the effects of intracranial and intra-orbital lesions as well as to those of local lesions. A noteworthy fact is that deformity of this fissure ranks second in incidence among roentgen manifestations of intracranial neoplasms (15). The floor of the orbit is also a point of weak resistance to tumor pressure within the orbit or

maxillary sinus. The lamina papyracea is another point which easily gives way to pressure. For accurate determination of the direction of pressure at these levels, it is essential that both frontal and lateral laminagrams be made.

The similar clinical manifestations of various lesions in this region frequently contribute to errors in diagnosis. It is estimated that 60 per cent of orbital inflammations originate in the sinuses, while only 2 to 3 per cent of sinus inflammations cause orbital lesions (18). Although the incidence of sinus carcinoma is less than that of sinusitis, 22 per cent of sinus carcinomas penetrate the orbit. Thus, malignant sinus tumors give rise to orbital complications six to ten times more frequently than sinus inflammatory conditions. In Godtfredsen's series (18), 71 per cent of sinus tumors extending into the orbit presented unilateral exophthalmos with dislocation of the eyeball, and 50 per cent had associated trigeminal neuralgia. However, Pfeiffer (19) states that the commonest cause of unilateral exophthalmos is mucocele of the frontal sinus. Tassman (9) quotes Holan, stating that carcinoma of the sphenoid sinus has five routes of extension in order of frequency: orbital, nasal, cranial, petrosal, and occipital. Tassman's patient and one other (20) had headaches, epistaxis, and ophthalmoplegia, and the roentgenograms in each instance showed hazy ethmoids and destruction of the walls of the sphenoid sinus. Late roentgenograms in a case of pansinal mucocele (a mucocele occurring in the antrum associated with one in the sphenoid on the same side) showed extensive bony destruction originally thought to be due to carcinoma (6). With orbital involvement from malignant nasopharyngeal tumors, exophthalmos is rarer and occurs late in the disease.

Thus, it is seen that, while signs and symptoms may not indicate the presence of a lesion in the region of the orbital inlet, early roentgen changes in the local anatomy may be significant in suggesting its presence and even its origin.

*Clinical Findings:* The clinical picture depends on the following factors:

(1) The escape of secretions, which may be occasional, chronic, or periodic. A history of chronic sinusitis is not always obtained. Sometimes the patient relates that he has had a sudden copious nasal discharge, which may be watery or viscid, contain fresh or old blood, and which may occasionally be followed by simultaneous relief of the pressure symptoms.

(2) Structures directly affected by the pressure of the expanding lesion. (a) The generalized increase in pressure probably contributes to the headaches, which are frontal and temporal and often associated with an aching in and about the eye on the involved side. (Peculiarly, the left side is involved more often than the right, while sex or age appears not to influence incidence.) (b) Pressure on the optic nerve, present in almost all cases, causes some visual disturbance, ranging from diplopia and varying degrees of scotoma to optic atrophy and total blindness. (c) Displacement of the orbital contents occasionally produces a unilateral exophthalmos, which infrequently is pulsating (21). (d) Irritation of the gasserian ganglion may cause facial pain. (e) Olfactory disturbances, convulsions, and unconsciousness have been reported.

Rhinologic examination usually is negative, although some edema of the turbinates or other sign of sinusitis may be found and slight bulging of the anterior wall of the sphenoid sinus may be observed.

Ophthalmologic examination may or may not reveal exophthalmos. Extraocular movements may be normal, limited or absent, depending on the extent of involvement. Fundoscopic examination usually is negative, but early in the course of the disease optic neuritis or retrobulbar neuritis is suspected, and later on optic atrophy is discovered.

Radiologic examination may contribute most to the diagnosis. Such examination should be considered adequate only if there is satisfactory demonstration of the superior orbital fissures, optic foramina,

lateral walls of the ethmoid sinuses, floor of the sella turcica, walls of the sphenoid sinuses, lesser wings of the sphenoids, and walls of the orbits. The radiologic findings include changes of the sella turcica, such as erosion and destruction of the floor (Fig. 2B), with occasional concomitant changes in the anterior and posterior clinoids, all of which may be unilateral and asymmetrical. Similar pressure changes might be expected earlier, for reasons previously described, about the sphenoidal fissure and optic canals (Fig. 3), with associated widening and irregularity. Lateral displacement of the lamina papyracea (Fig. 1) usually occurs, and the erosion of this bony plate often produces a loss of marginal continuity, which in some projections may be mistaken for a calcified structure, such as a vessel or an aneurysm. Frontal laminagrams may demonstrate the projection of the sphenoid sinus below the level of the middle cranial fossa and destruction of the floor of the sella turcica. The lateral boundaries of the mucocele, as well as involvement of the jugum sphenoidale (superior surface of the sphenoid body), are also more fully appreciated on laminagrams (Figs. 4 and 5). Changes in the walls of the orbit depend on the duration of increased intraorbital pressure, which certainly is a late manifestation.

*Differential Diagnosis:* A congenital anomaly, such as defective development of the sphenoid bone (22), is usually associated with unilateral pulsating exophthalmos. Visual disturbances are not necessarily present, although they are frequent when neurofibromatosis occurs simultaneously. Radiographic findings in such cases include: an enlarged orbit with depression of its floor; absence of shadows corresponding to the orbital plate of the frontal bone and wings of the sphenoid; narrowing of the ethmoidal cells medial to the orbit; and the appearance of the lateral wall of the sphenoid closer to the median line. The optic foramen, the foramen ovale, and the foramen spinosum may be absent as well. Thus, a congenital defect could be erroneously diagnosed as sar-

coma of the orbit with destruction of its walls. An encephalogram may show a collection of gas extending well into the orbit, suggesting an encephalocele. The absence of distressing symptoms, the presence of slow deliberate pulsations, and the absence of a bruit differentiate it from an arteriovenous aneurysm. In the latter, the pulsations are less marked and there is often dilatation of retinal and neighboring vessels.

In orbital meningocele or encephalocele, the encephalogram usually shows the gas protruding into the orbit from the cranium through a gap between the cribriform plate and the orbital plate of the frontal bone, and between the orbital plate of the frontal bone and the lamina papyracea. Since the defect is anterior, the eye is displaced laterally and downward but is not unduly prominent.

Other causes of bony defects about the orbit in pulsating exophthalmos (20) are dermoid and epidermoid tumors, which commonly cause circumscribed dehiscences with smooth margins and with increased density of the surrounding bone. Metastases and xanthomatosis produce erosions which are usually irregular.

Optic nerve and chiasmatic gliomas cause circular enlargement of the optic canal, and in children such tumors are the most likely possibilities if retinoblastoma and neurofibromatosis can be ruled out (20).

Meningioma of the sphenoid ridge, which is a common erroneous diagnosis of sphenoid mucocele (13), is the most frequent cause of hyperostosis of the orbit, particularly when the meningioma is situated at the medial portion of the ridge. In this location, the meningioma causes irregular enlargement and thickening of the optic canal. In one case (23) this hyperostosis of the orbit was sufficient to cause anterior displacement of the orbital contents. However, meningiomas occasionally cause decreased bony density. Paget's disease and hyperparathyroidism can produce a similar hyperostosis, but it ordinarily is bilateral.

Suprasellar, intrasellar, and parasellar tumors probably are among the most difficult to differentiate clinically, especially radiographically. It is suggested that, in a patient suspected of having any such lesion, complete radiologic demonstration of the structures mentioned previously be performed. In cases of pituitary tumors that are associated with changes of the sella turcica, destructive changes localized to the inferior strut of the optic canal are most significant, since an aneurysm of the extradural portion of the carotid siphon often erodes this strut (24).

The importance of an accurate diagnosis is obvious. The patient is spared a needless craniotomy and also the possible development of meningitis. Moreover, vision may be preserved in early cases.

**Treatment:** Treatment of a sphenoid mucocele consists of marsupialization of the mucocele cavity into the nasal fossa. The artificially created ostium must be of sufficient size to prevent subsequent occlusion in the healing process and should be as large as is technically feasible. The route for this procedure may be by way of the standard external ethmoid exposure or it may be transnasal, depending on the experience of the surgeon.

#### SUMMARY

1. The lack of accurate clinical diagnosis and detailed radiographic descriptions of mucocele of the sphenoid sinus in the literature is pointed out.

2. Two cases with their radiographic findings are reported.

3. The syndrome that indicates the possible presence of this lesion is briefly discussed, and the term "orbital inlet syndrome" is suggested to describe it.

4. The origin and pathogenesis are considered. Inherent structural weaknesses of the orbital inlet are described and the peculiarities of certain lesions in this region having similar clinical manifestations are presented.

5. Clinical findings are compiled with emphasis on the radiologic characteristics.

6. The differential diagnosis and the treatment are given.

Cleveland Clinic  
2020 E. 93rd St.  
Cleveland 6, Ohio

#### REFERENCES

1. PETIT-DUTAILLIS, D., THIEBAUT, F., AND FISCHGOLD, H.: Contribution à l'étude des compressions intracrâniennes des nerfs optiques par les abcès ou les mucocèles extradurales d'origine sphéno-ethmoïdale. *Rev. neurol.* **83**: 325-341, November 1950.
2. FISCHGOLD, H., PROT, D., AND FISSORE, A.: Altérations unilatérales de la clinodole antérieure dans les néoformations du carrefour sphéno-orbitaire. *Presse méd.* **59**: 400-402, March 28, 1951.
3. PETIT-DUTAILLIS, D., AND FISCHGOLD, H.: A propos de la discussion sur l'examen radiotomographique dans les exophthalmies unilaterales. *Rev. neurol.* **83**: 386-387, November 1950.
4. LINTHICUM, F. H., RAND, C. W., AND REEVES, D. L.: Mucocele of the Sphenoid Sinus. Report of a Case with Autopsy Findings. *J. Neurosurg.* **3**: 444-453, September 1946.
5. GIOVINE, G.: Sindrome visiva ed oculo simpatica da mucocele del seno sfenoidale. *Chirurgia* **1**: 179-183, September 1946.
6. ANTHONY, W. P., AND WILLIAMS, H. L.: Unilateral Pansinal Mucocele Simulating Malignant Neoplasm. Report of Case. *Arch. Otolaryng.* **53**: 189-194, February 1951.
7. LABAYLE, J.: Mucocele du sphénoïde. Société de Laryngologie des Hôpitaux de Paris. *Ann. d'otolaryng.* **66**: 683-685, 1949; as quoted by Petit-Dutaillis et al. (1).
8. HOLT, H., AND DE RÖTT, A.: Orbital Apex and Sphenoid Fissure Syndrome. *Arch. Ophth.* **24**: 731-741, October 1940.
9. TASSMAN, I. S.: Complete Unilateral Ophthalmoplegia Due to Primary Carcinoma of Sphenoidal Sinus; Sphenoidal Fissure-Optic Canal Syndrome with Complete Ophthalmoplegia. Report of Case. *Arch. Ophth.* **37**: 294-303, March 1947.
10. HERMAN, K., AND HALL, I. S.: Sphenoid Mucocele as a Cause of the "Ophthalmoplegic Migraine Syndrome." *Tr. Ophth. Soc. U. Kingdom* (1944) **64**: 154-164, 1945.
11. WIGH, R.: Mucoceles of the Fronto-Ethmoidal Sinuses. Analysis of Roentgen Criteria. Relation of Frontal Bone Mucoceles to Ethmoidal Sinuses. *Radiology* **54**: 579-590, April 1950.
12. WILKERSON, W. W., JR.: Mucocele of the Nasal Accessory Sinuses. *Laryngoscope* **55**: 294-308, June 1945.
13. VINCENT, C., THIEBAUT, F., AND DAUM: Les abcès extra-duraux d'origine sphéno-ethmoïdale. *Rev. de méd.*, Paris **60**: 166-171, July-October 1943.
14. PFEIFFER, R. L.: New Technique for Roentgenography of the Optic Canals. *Am. J. Roentgenol.* **29**: 410-415, March 1933.
15. KORNBLOM, K., AND KENNEDY, G. R.: The Sphenoidal Fissure, an Anatomical, Roentgenological and Clinical Study. *Am. J. Roentgenol.* **47**: 845-858, June 1942.
16. BAYLIN, G. J., AND KERMAN, H. D.: Roentgen Examination of the Sphenoidal Fissures. *South. M. J.* **40**: 281-289, April 1947.
17. DAVID, M., FISCHGOLD, H., BREGEAT, P., TALAIRACH, J., AND FISSORE, A.: Étude radio-tomographique de la pression tumorale dans l'exophthalmie unilatérale. *Rev. neurol.* **83**: 379-386, November 1950.

18. GODTFREDSEN, E.: Studies on Orbital Tumors; Exophthalmos Due to Malignant Tumours in Paranasal Sinuses. *Acta Ophth.* **25**: 295-310, 1947.
19. PFEIFFER, R. L.: Roentgenography of Exophthalmos with Notes on the Roentgen Ray in Ophthalmology. *Am. J. Ophth.* **26**: 724, July; 816, August; 928, September 1943.
20. Massachusetts General Hospital Case No. 34482: Transitional Cell Carcinoma of Sphenoid Sinus. *New England J. Med.* **239**: 837-839, Nov. 23, 1948.
21. O'SHEA, H. V.: Pulsating Exophthalmos Due to Sphenoidal Sinus Mucocele. *Lancet* **1**: 1253-1254, June 11, 1932.
22. ROBERTSON, E. G.: Pulsating Exophthalmos Due to Defective Development of the Sphenoid Bone. *Am. J. Roentgenol.* **62**: 44-51, July 1949.
23. BREGEAT, P., FISCHGOLD, H., DAVID, M., AND FISSORE, A.: Étude radiographique de la capacité orbitaire dans un cas de méningiome du sphénoïde. *Rev. neurol.* **85**: 459-463, 1951.
24. ENGESET, A., AND TORKILDSEN, A.: On Changes of the Optic Canal in Cases of Intracranial Tumor. *Acta radiol.* **29**: 57-64, 1948.

## SUMARIO

**El Síndrome Asociado con Mucocele del Seno Esfenoidal. Presentación de Dos Casos con Sus Hallazgos Radiográficos**

Presentan 2 casos de mucocele del seno esfenoidal y se propone el término de "síndrome de la abertura orbitaria" para describir las combinaciones de signos y síntomas de dicha afección, comprendiendo cefalalgia y anomalías oftalmológicas, dolor facial y a veces exudado nasal. Radiológicamente, observan alteraciones en la silla turca, tales como erosión y destrucción del suelo, con ocasionales alteraciones concomitantes en los clíndoides anteriores y posteriores y alteraciones semejantes alrededor de la fisura esfenoidal y los canales orbitarios, junto con dilatación e irregularidad. Suele haber desplazamiento lateral de la lámina papirácea. Los

laminogramas tal vez revelen la proyección del seno esfenoidal por debajo del nivel de la fosa craneal media y destrucción del suelo de la silla turca. Mostrarán además los límites laterales del mucocele, e igualmente la invasión de la cara superior del esfenoides.

La semejanza en las manifestaciones clínicas de varias lesiones de esa región contribuye frecuentemente a los errores de diagnóstico. Se recalca la importancia del diagnóstico acertado, dado que puede impedir una craneotomía innecesaria y la posible aparición de meningitis. El tratamiento consiste en la marsupialización de la cavidad del mucocele en la fosa nasal.



## A Method of Dosimetry for Carcinoma of the Cervix Utilizing a Modified Manchester Technic with Cobalt 60

I. MESCHAN, M.D.,<sup>2</sup> T. H. ODDIE, D.Sc., F. Inst. P.,<sup>3</sup> and GEORGE REGNIER, M.D.<sup>4</sup>  
with the Technical Assistance of Clifton C. Young and Calvin C. Jackson

**I**N THE TREATMENT of carcinoma of the cervix, the best dose-time relations have not been established for cervix, bladder, rectum, and pelvic lymph nodes. It would be most desirable if dosage could be expressed in terms of energy *absorbed* in each tumor-bearing area, but unfortunately this is not yet feasible. It is our present aim, therefore, to express the dosage *delivered* to the tumor-bearing area, and the "roentgen" has been accepted as the unit of such dosage. Certainly the milligram-hour and the millicurie-hour are merely units designating a quantity of radiant material and are *in no way* indicative of dose delivered to a given area or dose absorbed.

The advantages of accurate dose determination are obvious: Results in different clinics may be more readily understood, compared and duplicated; treatment may be individualized for each patient; when complications occur, their etiology can be more accurately analyzed and their prevention in other patients anticipated.

It is not suggested that a system of dosimetry will supplant clinical judgment in the application of radiation, nor that a tumor-bearing area can be described with mathematical exactitude by reference to certain anatomical "points" which merely furnish a convenient index. Also, it is to be emphasized that when a combination of gamma roentgens and x-ray therapy is utilized, with considerably different time intervals for each, the two cannot be summated. If, however, the dose and time of each are understood and predicated, this summation may be utilized as an index, of

which the component parts are known and not interchangeable.

One further point requires emphasis: In our clinic (9) about 25 per cent of patients who die from carcinoma of the cervix at present do so because the disease has progressed beyond curable limits by the time they are first seen. To better our survival rates, improvement in the sociological problem of education of the public as to early symptoms and signs is first necessary.

In approximately 15 to 25 per cent of patients with cervical carcinoma, the localization of the disease will be incorrectly estimated and extension outside the pelvis will have occurred despite clinical appraisal to the contrary at the initial examination. Approximately 10 to 15 per cent of patients in our experience have radio-resistant carcinoma. Five-year-survival figures can thus be no better than 35 to 45 per cent of all cases seen under these circumstances, and 4 per cent of those treated will have serious sequelae. There is undoubtedly a place for improvement of our radiation technic so that the incidence of complications can be reduced, and this theoretical ideal of 35 per cent can be achieved. In the group outside the theoretical 35 per cent, improvement in dosimetry, applicators, technic of radiation, etc., will not have a significant effect, but it will be of help in reducing serious sequelae and complications and may bring about an increase in survivals in some institutions.

The purpose of this paper is to describe

<sup>1</sup> From the Department of Radiology, University of Arkansas School of Medicine, Little Rock, Ark., Research Series No. 995. Accepted for publication in May 1954.

With the assistance of grants-in-aid from the National Institute of Health (C-1866), the Damon Runyon Memorial Fund for Cancer Research, and the Atomic Energy Commission, Contract #AT-(40-1)-1078.

<sup>2</sup> Professor and Head of the Department of Radiology, University of Arkansas School of Medicine.

<sup>3</sup> Visiting Assistant Professor, Department of Radiology, University of Arkansas School of Medicine, on Fulbright Fellowship.

<sup>4</sup> Assistant Professor, Department of Radiology, University of Arkansas School of Medicine

a new applicator, noting deficiencies in presently used methods and the need for revising these to some extent. A typical clinical problem is evaluated, and long and short methods of calculating dosage are given for this particular case.

#### DESIGNATION OF INDICES OF ADEQUATE RADIATION TO THE PELVIS

We have defined certain anatomical fixed "points" within the pelvis toward which therapy is directed and which will serve as a basis for our calculations, in which gamma and x-ray roentgens are summated for convenience. It is not meant that designated points in the pelvis, or summated gamma and x-ray roentgens, have any great significance in and of themselves. These tabulations are *indices only*, to assist in the clinical management of carcinoma of the cervix. As is the case with all formulae, coefficients, and the like, the component parts must be understood.

We have felt that more attention should be directed to the lateral wall of the pelvis, the bladder, and rectum, the areas to which spread may occur and which may be responsible for the ultimate death of the patient while the cervical lesion may itself be healed.

The "points" in the pelvis which we are tabulating and using for reference are as follows:

1. *Point C*, 0.7 cm. lateral to the center of the external os of the cervix.
2. *Point C<sub>1</sub>*, 0.7 cm. superior to the center of the external os of the cervix.
3. *Point A*, Tod's (12) point A, which is 2.0 cm. superior to the level of the lateral fornix and 2 cm. lateral to the central uterine axis. (Tod stated that she considered the cervix eroded and that the external os was usually at the point of crossing of the uterine artery and ureter. While this is not usually so, point A, in many years of application, has been proved to be a valuable index point.)
4. *Point W*, indicating the lateral wall of the pelvis, where the obturator lymph node is usually found. This is arbitrarily

taken as 6 cm. lateral to the central uterine axis and 2 cm. up from the level of the lateral fornix. (This point is therefore 1 cm. lateral to Tod's point B, which we have found not so good an index of irradiation to the lateral pelvic wall in the average case, and which we do not use.)

5. *Point Bl*: This point, on the posterior wall of the base of the urinary bladder, is obtained as follows: Five cubic centimeters of sodium iodide are placed in the Foley bag of the indwelling catheter and the bag is pulled down upon the bladder trigone. On a lateral film of the pelvis (corrected for magnification) a point is designated which is 5 mm. from the nearest posterior margin of the bag to the intracavitary applicator (Fig. 1A). This would indicate the *serosal* surface of the bladder near its base. Admittedly, this does not necessarily indicate the dose to the urinary bladder, since the bladder wraps itself in variable fashion around the uterus. We have, however, found this point to be a useful index.

6. *Point R*, the point on the rectum which is nearest to the intracavitary applicator. The rectum and the sigmoid are coated with moderately thick barium sulfate (not distended), and on the lateral radiograph of the pelvis, corrected for magnification, this point is found. Care is exercised to make sure that this is a mid-line point as seen on the anteroposterior view of the pelvis and that it does not represent a loop of redundant sigmoid situated laterally. Occasionally, when an enterocele is present, the nearest intestinal loop other than the rectum is taken.

On the basis of past experience with approximately 150 cases over a three-year period, and in the light of microscopic studies of the pelvic tissues in a group of 26 operated cases previously reported (2), we have selected certain dosage levels which we endeavor to obtain in each patient at the points designated above. These may be tabulated as follows<sup>5</sup>:

<sup>5</sup> The gamma radiation is given in one or two fractions in a total of four to seven days, in continuity with fractionated x-ray therapy in an average of five weeks.

DOSAGE LEVELS AT DESIGNATED POINTS  
(8 X 15-cm. ports; 220 kvp; h.v.l. 1.5 mm. Cu)

Pelvic Point	Gamma r	X-ray r
C and C <sub>1</sub>	7,000 to 14,000	2,000
A	7,000	2,000
W	1,500 to 2,000	3,500 to 4,000
BL (maximum)	4,000	2,000
R (maximum)	4,000	2,000
Skin tolerance	...	3,300

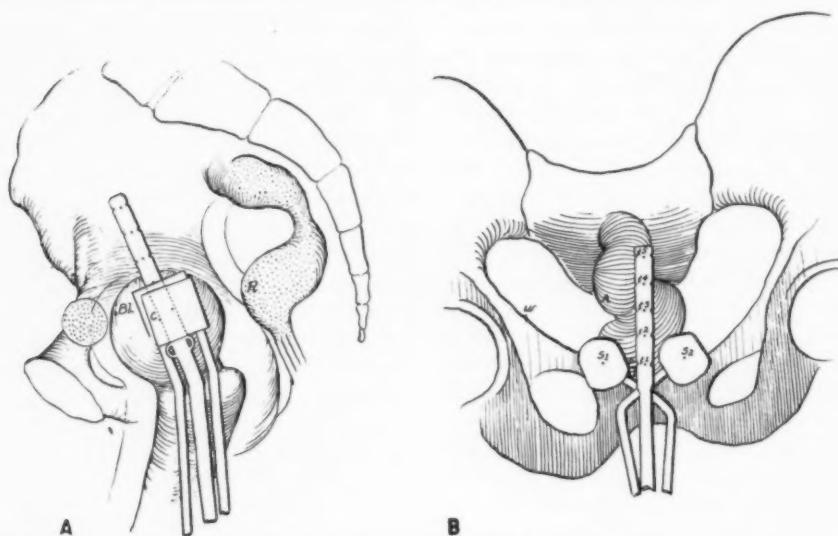


Fig. 1. Line tracings of the lateral and anteroposterior views of the pelvis showing the cervical applicator in position and its relationship to the various points of interest in the pelvis. The Foley bag catheter in the urinary bladder contains 10 per cent sodium iodide and the rectum has been streaked with barium.

NEW APPLICATOR: ITS DESIGN

(Figure 2)

Many types of applicator have been designed for the intracavitary treatment of carcinoma of the cervix. Most of these involve some form of paracervical application of the gamma-ray source plus a tandem stem in the cervical canal, usually applied to the full length of the uterus. The isodose patterns derived are pear-shaped. In the earlier Manchester, Paris, and Stockholm technics, this T-shaped arrangement had no rigidity between the colpostat portion and the uterine tandem. In such cases, the calculations and conversions to gamma roentgens for a given application were time-consuming and impractical for everyday use.

Rigid or partly rigid applicators afford

several advantages: The actual application can be made more readily and, as a result, there is less exposure of personnel involved in the application. The calculation in terms of gamma roentgens becomes more feasible with a technic such as we propose. Immobilization of the sources and predetermination of their position are

accomplished more readily and more certainly in two projections. Rigid applicators have been designed by Campbell (3) and Ernst (5), and additional lead or tungsten filtration has been incorporated in the colpostat by Cuscaden and Oddie (4), Ernst (5), and Fletcher (6, 7).

With the Campbell and Ernst types of expanding colpostat, there is a tendency to overdosage of the vaginal wall, especially in the lateral fornices, and a greater distance between the vaginal wall and radiant source is desirable, such as is supplied by the Manchester ovoids. Moreover, the spreading mechanism in the Ernst applicator frequently "jams." We have found that such screw mechanisms, when encased, must be frequently re-packed with grease to assure ease of application.

The rigid applicator of the Fletcher de-

sign (7) overcomes the disadvantage of the Ernst applicator and adds the advantages of rigidity to the Manchester ovoids, but it does not afford a rigid relationship between the ovoids and the tandem. The contribution of the tandem to the bladder in this method is not readily calculated,

B). The tandem sources consist of 1.0-cm. capsules joined in series, with a notch at the center of the source which will appear on the radiograph. Three different tandems are employed, depending on the length of the uterine cavity: the *short* tandem consists of three capsules; the *medium* tandem

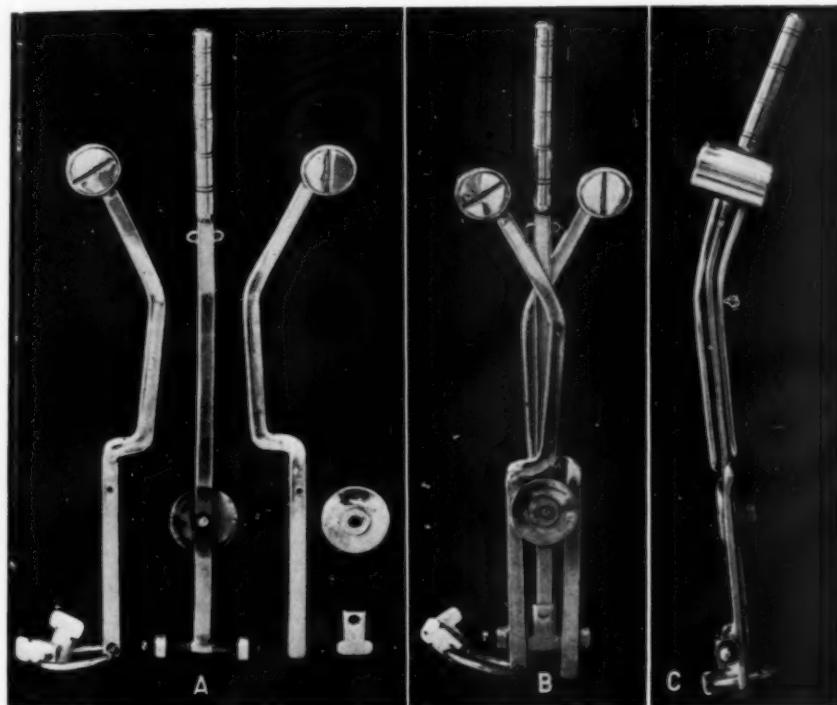


Fig. 2. Photographs of the rigid applicator of our newest design. A. Disassembled, showing how the tandem and the two colpostats may be inserted separately. B. Assembled in frontal projection. C. Assembled in lateral projection. In A the "spacers" are shown adjoining the applicator. These are set for  $a = 1.75, 2.0$ , or  $2.5\text{ cm}$ . ( $a = 3$  is not recommended.)

even as an index, without time-consuming spatial reconstruction, since it is not rigidly fixed with the colpostat.

With this deficiency (in our opinion) of the Fletcher applicator in mind, we have designed a specially constructed rigid applicator which employs all of the advantages of the Manchester system, and still has a fixed tandem in relation to the colpostat sources. Also, a method of fixation to the cervix is provided. The tandem and then the individual colpostat sources are each inserted separately, and re-assembled after insertion (Fig. 2, A and

B of four capsules; and the *long* tandem of five capsules.

The colpostat sources are shown in longitudinal section in Figure 3. These consist of a cobalt 60 slug 1 cm. in length and 0.32 cm. (1/8 inch) in diameter, centrally spaced in a capsule 2 cm. in diameter. The spacer is made of wood, and the capsular wall is 2 mm. of brass. There are disks of lead 5 mm. in thickness superiorly and inferiorly, almost the full diameter of the capsule, helping to shield the bladder and rectum.

Calibrated spacers are applied exter-

nally, and thus a known separation of the colpostat capsules is obtained. From the physical calculations it is found that usually the 6- or 7-cm. spread of the colpostats gives the most satisfactory distribution of dosage to the pelvis. (The reader is referred to the following paper for

*Stage I without Parametrial Inflammation:* Immediate intracavitary irradiation is planned to give the total dose in four to seven days, in one or two applications. If two applications are used, they may be separated by an interval of seven to fourteen days, with external x-ray irradiation

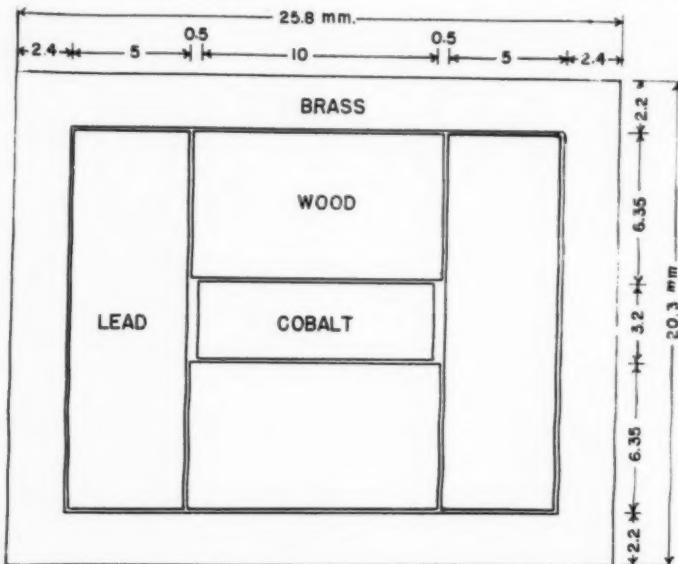


Fig. 3. Diagram of a longitudinal section through one of the presently used colpostat sources (S).

further elaboration of this point). Also from physical calculations it can be derived that the most desirable dosage distributions are obtained when the bladder point is in a negative or zero position with reference to the  $z$  axis. Unfortunately, this ideal is not always obtainable. If the bladder point is at a higher than  $z = +2$ -cm. position, it is probable that an inadequate dosage distribution will be obtained, and supplementation by transvaginal x-ray and external irradiation will be necessary.

#### GENERAL DESCRIPTION OF METHOD OF TREATMENT

All patients are carefully examined in collaboration with the Department of Gynecology (Dr. Willis E. Brown, Chairman), and staging and method of treatment are decided upon jointly. The usual approach is as follows:

all the while. The external radiation is administered over five continuous weeks, making a total of six weeks for the two modalities. The physical factors for the roentgen therapy are: 220 kvp, 15 ma, 50 cm. skin-target distance, h.v.l. 1.5 mm. Cu. When the patient's measurements exceed 20 cm. anteroposteriorly, there is slight advantage in using 400-kvp therapy if such is available, and that is our practice (skin-target distance 65 cm., h.v.l. 3.8 mm. Cu).

It may be argued that in these cases the external irradiation is unnecessary, since the local disease is cured by the intracavitary gamma-ray medium and there is supposedly no tumor outside the confines of the cervix. Unfortunately, it has been repeatedly demonstrated by Taussig (11), Morton (10), Henriksen (8), and others that our clinical evaluation and staging by

League of Nations standards is erroneous in about 25 per cent of the cases at best. Our own experience with a smaller series is in agreement with this concept, and we are not quite willing to deny our Stage I patients the benefit of treatment to the entire pelvis.

*Stage I with Parametrial Inflammation and Stage II:* Treatment is begun in these cases with external x-ray irradiation to six or eight pelvic ports, cross-firing at the lateral pelvic wall (point W) on each side—not the cervix. A lead strip 4 cm. wide is utilized down the middle of the pelvis, both anteriorly and posteriorly, so that no direct radiation is applied to the tissues 2 cm. from the mid-line on either side, which seems to help in the protection of the bladder and rectum. Two anterior and two posterior 8  $\times$  15-cm. fields and two sacrosciatic 10  $\times$  10-cm. fields are always employed, to which are added 10  $\times$  10-cm. gluteal ports when extra dosage is still necessary to the lateral pelvis. Usually two fields are treated daily, each getting 300 r on the skin after the first round, for which smaller dose levels are employed. After seven to fourteen days of such treatment, intracavitary gamma-ray therapy is given as described above, in one or two fractions over a period of five to seven days. If more than one intracavitary application is given, x-ray therapy is continued between applications. When a total of 3,500 to 4,000 r (x-ray) are delivered (tissue dose) to the lateral pelvis, usually about 2,000 r have been delivered to the cervix, rectum, and bladder, even though the lead protection strip is applied, and though the center of the cross-fire has been the lateral pelvic wall.

*Stage III with No Vaginal Extension Below the Upper Third of the Vagina:* If the vagina is small, and it is anticipated that there will be difficulty in the intravaginal application of the gamma-ray medium, a regime similar to that for Stage II patients is followed. If no difficulty in application of the gamma-ray medium is anticipated, all of the external radiation is given first in these patients, and the in-

tracavitary radiation is then applied in one or two continuous or almost continuous sessions. It is hoped that with this plan there will be a maximum shrinkage of the tumor-bearing area prior to application of the gamma-rays, so that the latter will be most efficacious for the entire tumor-bearing area. The number of x-ray ports and the method of applying intracavitary dosage are otherwise the same.

*Stage III with Vaginal Extension Below the Upper Third of the Vagina:* In addition to the applications described above, a tubular source is applied in the vagina or, if the disease is sharply localized and amenable to interstitial implantation, the latter is advised. If rectovaginal or vesicovaginal fistulas result, various surgical procedures may be employed in an effort to rectify these complications if the patient is tumor-free some months later.

*Stage IV:* Ordinarily palliative external x-ray irradiation is all that can be utilized in Stage IV cases, and in such instances the external therapy is modified as follows. Instead of cross-firing at the lateral pelvic wall, all of the ports are cross-fired at the cervix and vagina. The mid-line lead protective strip is reduced to 2 cm. width instead of the 4 cm. employed when intracavitary irradiation is contemplated. Various surgical palliative measures have also been employed in these cases as needed, for which the reader is referred to a previous report (9).

#### SAMPLE CASE WITH RESPECT TO CALCULATIONS

A white female, age 34 years, presented herself at the University Hospital Clinic with a history of post-coital bleeding for the past several weeks. Examination revealed an eroded lesion of the cervix and biopsy was reported as showing "squamous-cell carcinoma, Grade II." The patient was immediately referred to the gynecology tumor clinic, where the history, physical examination, blood chemistry, blood cellular studies, and excretory pyelograms were found to be essentially normal. She was presented at the next weekly meeting of the joint gynecology-radiology conference, and there, after examination and review of findings, it was determined that the lesion was of Stage I (League of Nations). The plan of treatment was therefore intracavitary irradiation, followed by external irra-

diation to six skin fields—anterior, posterior, and sacrosciatic—in five to six weeks as tolerated. The two anterior and posterior fields were to be treated individually and a 4-cm. strip of untreated skin left between them down the mid-line. All beams were to be directed toward a parametrial point some 6 cm. from the mid-line (anterior and posterior beams to be directed vertically downward). It was deter-

necessary to apply packing to hold the sutured applicator in position.

The patient was then removed to the X-Ray Department, where a catheter was introduced into the rectum and several ounces of a thin barium mixture were instilled by bulb syringe. A lateral film of the pelvis at approximately 6-feet target-to-film distance was obtained and viewed. By determination of the

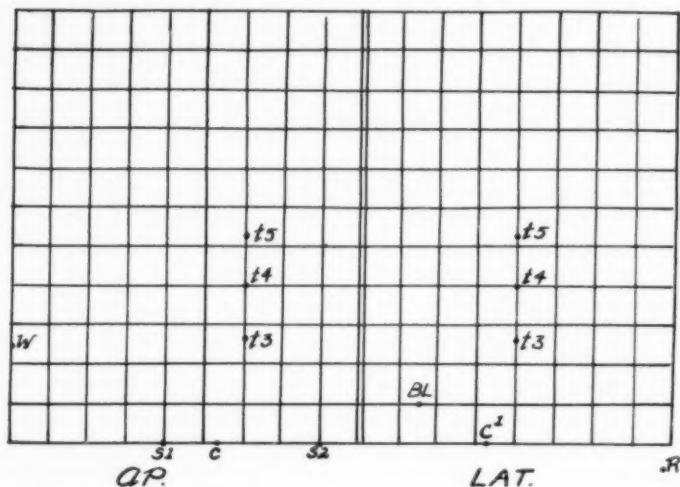


Fig. 4A. Centimeter grid for a permanent record of the centers of each of the sources, as determined from films, in relation to the pelvic points on the anteroposterior and lateral projections. By using a common point of reference on the applicator, correction can be made by direct tracing from the radiograph for magnification, since the sources are all in constant and known relationship to one another. Such a grid record can be made by direct tracing from the radiograph if teleroentgenograms are used. However, if such films are not available, the grid is very helpful in visualizing the two views together after correction for magnification. The lateral view would usually be magnified more than the anteroposterior.

mined by probing the uterine canal that the long cervical applicator could be used.

The patient was admitted to the hospital and, under saddle anesthesia, the cervix was dilated in the operating room and the cobalt applicator applied. Before the actual insertion, strong sutures were passed through the anterior and posterior lips of the cervix, and a skin clip was attached to the lateral lip. The only reason for marking the cervix with a metallic clip is that from the films we can estimate the degree of apposition between cervix and applicator. The tandem was then inserted and the sutures were tied through the eyes provided, holding it in close approximation to the cervix. The individual colpostat arms were introduced and slipped over the pins and locked in place. A Foley bag catheter was inserted, and the bag filled with 10 per cent. sodium iodide. The colpostat arms were then spread (2-cm. spreader), the bladder and rectum were packed away as well as possible, and loose packing was applied in the vaginal vault, it not being

relationship of the axis of the tandem and the plane of the sacrum, the patient was positioned for the anteroposterior view. The hips or the shoulders were elevated, as needed, to bring the applicator as nearly parallel with the film as possible. As a rule of thumb, the axis of the tandem must be at least 2.5 cm. distant from both the rectum and bladder points if one hopes to obtain a satisfactory dosage to the various other points. If the films appear satisfactory, the patient is sent to the ward and the films are processed in the usual manner. If unsatisfactory, readjustment is necessary.

On the dry films the centers of the various sources may be determined and the cervix and wall points noted. Point A on either side is taken as a point 3 cm. along the tandem axis and 2 cm. lateral to the tandem, and the cervix is defined, these three points forming the paracervical triangle. The nearest points of rectum and bladder are marked on the film. In the case of 6-foot films it is possible to make measurements directly on the film, because of the

WAVE M-----F-----

UNIT NO. A-----

APPLIED BY	I. Neachan		
DATE	5-5-53	TIME	9 A.M.
REMOVED BY	G. Regnier		
DATE	5-8-53	TIME	9:05 P.M.
CALCULATED BY	T. H. Oddie		

## TOTAL ROENTGENS (Rounded-off Figures)

RECTUM	R	1710
BLADDER	BL	4000
CLIP POINT	C <sub>1</sub>	11260
CERVIX	90° X	8100
LEFT WALL	LW	1420
RIGHT WALL	RW	1420
PARACERVICAL	A	6900

TRIAL CALCULATION (BLADDER)						
No.	Distance		r/mc	Mc	r/hr	
	L	H	hr			
S1	2.5	2	.75	13.1	9.83	
S2	2.5	2	.75	13.1	9.83	
T2	1.5	2.5	1.3	19.0	24.70	
T4	2.9	2.5	.75	1.57	1.18	
T5	4.2	2.5	.45	3.5	1.58	
6						
7						
8						
9						
10						
11						
12						
Total r/hr to this point 47.1						

Mc hr No. Mg	RECTUM				CERVIX (C)				CERVIX (C <sub>1</sub> )					
	Distances		r/mc	Total	Distances		r/mc	Total	Distances		r/mc	Total		
	L	H	hr	r	L	H	hr	r	L	H	hr	r		
S1	1102	4	4.2	.4	441	0	1.3	6.3	6943	.7	2	2.5	2755	
S2	1102	4	4.2	.4	441	0	2.7	1.53	1686	.7	2	2.5	2755	
T3	1598	2	8.4	.45	719	2.5	.7	1.52	2429	2.6	.7	1.52	2429	
T4	132	4	2.4	.3	40	3.9	.7	.69	91	3.9	.7	.69	91	
T5	244	5	5.4	.24	71	5.2	.7	.39	115	5.2	.7	.39	115	
					TOTAL	1712			TOTAL	11264			TOTAL	8145

Mc hr No. Mg	LEFT WALL				RIGHT WALL				PARACERVICAL TRIANGLE			
	Distances		r/mc	Total	Distances		r/mc	Total	Distances		r/mc	Total
	L	H	hr	r	L	H	hr	r	L	H	hr	r
S1	1102				0	4.5	.55	606	0	3	1.28	1411
S2	1102	SAME			0	8.5	.16	176	0	5	.45	496
T3	1598	AS			0	6	.33	527	.5	2	2.75	4395
T4	132	RIGHT			1.5	6	.30	40	1	2	2.3	304
T5	294				3	6	.25	74	2.5	2	1.1	323
					TOTAL	1423			TOTAL	6929		

Fig. 4B. Permanent record for sample case completely filled out. Since there are only five sources in the applicator now being used, the entries and calculations are relatively simple. The same form, however, may be used with more complicated applicators, such as the Ernst, which has nine sources. Indeed, we have on occasion modified the Ernst applicator and applied the method to 12 sources. A more rapid method of calculation is presented which is reasonably accurate and not nearly as time-consuming.

relatively low degree (5 to 8 per cent) of magnification. In other cases, and in our practice for record purposes, the points representing landmarks actually present on the films are transferred to a centimeter grid chart (Figure 4A) after correction for magnification. We have included our clinical chart for reference purposes (Figure 4B).

Once the proper points are determined, one is ready to begin measurements. For these the reader

is referred to Figure 1, A and B, which are tracings of this particular patient. (It should be emphasized that all measurements are taken from the central point in either axis.) In practice one usually determines the critical point which, as estimated by inspection, will get the greatest dosage, as this will usually be the limiting factor. In most cases this will be the bladder, a point 4 mm. nearer the applicator than the nearest point of the Foley bag. The

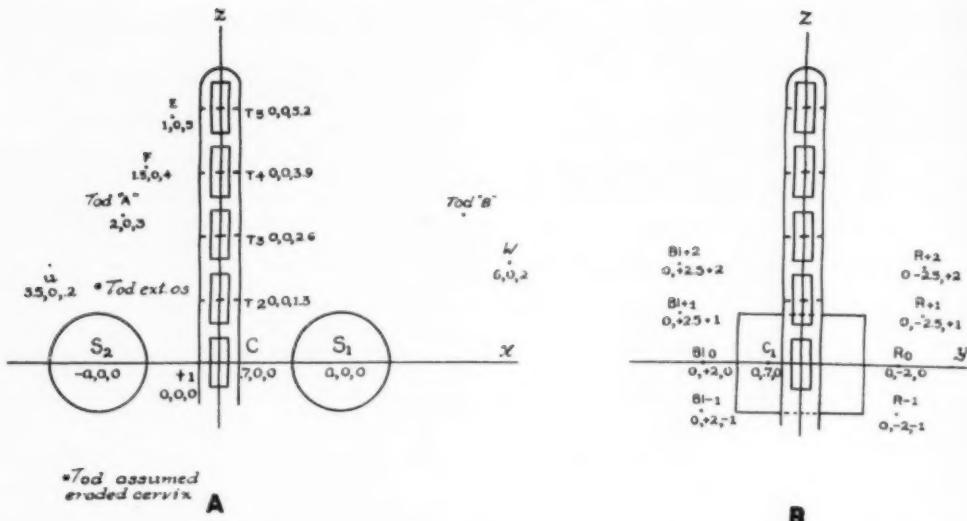


Fig. 5. Diagram of applicator in frontal (A) and lateral (B) projections, with pelvic points also indicated.

measurements from the colpostats to the bladder are made on the lateral film (Fig. 1A).

Figure 5 (A and B) shows the arrangement of the cobalt sources within tandem (T1, 2, 3, 4, 5) and colpostats (S1 and S2), respectively. The z axis is in the longitudinal line of the body, the x axis in the coronal plane and the y axis in the sagittal. In Figure 5B we see the various positions which the bladder may occupy with respect to y and z.

The first measurement represents  $l$  or distance along the same axis as the source and measured from its center. The second is  $h$ , the distance from the axis of the source. For the tandem sources the distance  $h$  is always the same as  $l$  for the colpostat sources, in this case 2.5 cm. This measurement remains the same for all tandem sources, but the measurement along the axis of the sources varies, being 1.6, 2.9, and 4.2 cm., as one goes toward the tip of the tandem, for T<sub>5</sub>, T<sub>4</sub> and T<sub>3</sub>, respectively. Once the measurements from the various sources to the point in question are obtained, one finds the dosage rate in r/mc-hr. from the isodose curves or from tables (Fig. 6, A and B, Table I-A and B). The first of these gives the figures for the colpostat sources and thus takes into account the lead filtration on their ends. One finds that the dosage rate to the bladder point is 0.75 r/mc-hr. ( $l = 2.5$ ;  $h = 2$ ) from each of the colpostat sources. Since each contains 13.1 mc, the r/hr. to the bladder point from each is 9.83. The second set of curves (Fig. 6B) gives r/hr. for the tandem source and it is found that source T<sub>3</sub> ( $l = 1.6$ ;  $h = 2.5$ ) gives 1.3 r/mc-hr. Since this source is 19 mc, it contributes 24.7 r/hr. to the bladder point. Source T<sub>4</sub> ( $l = 2.9$ ;  $h = 2.5$ ) contributes 0.75 r/mc-hr., and since this source is

1.57 mc, it contributes 1.18 r/hr. to the bladder point. The source T<sub>5</sub> ( $l = 4.2$ ;  $h = 2.5$ ) is 3.5 mc and gives 0.45 r/mc-hr., contributing 1.58 r/hr. The bladder then receives 47 r each hour. Knowing that 4,000 r is the maximum dosage we desire to the bladder, we know that the cobalt can be left *in situ* for a period of eighty-four hours only.

Measurements to the nearest point of the rectum are similar to those of the bladder, but in this instance the rectal point is 4 cm. from the axis of the tandem, so the total contribution is not significant. If the rectum were closer to the applicator than the bladder, the rectum would then be the limiting factor in our treatment.

Since the clip point C lies in line with the centers of the colpostats,  $l$  is zero and  $h$  is measured on the anteroposterior view of the x axis. The nearer of the two ( $h = 1.3$ ) gives 6.3 r/mc-hr., and the more distant ( $h = 2.7$ ) 1.53 r/mc-hr.

Being a constant distance from the axis of the tandem, the measurement  $h$  is 0.7 cm. for all tandem sources and the  $l$  distance is 2.6, 3.9, 5.2 cm. for sources T<sub>3</sub>, T<sub>4</sub>, and T<sub>5</sub>, respectively. From the isodose curves (Fig. 6B) we find that these give 1.52, 0.69, and 0.39 r/mc-hr., respectively. Multiplication of these dosage rates by the mc-hr. from each source gives the total r to the clip point C (11,260 r).

The second cervix point, C<sub>1</sub>, is the superior lip of the cervix and actually receives exactly the same dosage from the tandem sources as does C. For the colpostat sources, C<sub>1</sub> being equidistant from the two colpostats,  $l$  is 0.7 rather than 0, and C<sub>1</sub> receives a lower dosage from these two sources than does the other cervical point, C, which is not midway between the two colpostats (8,100 r).

TABLE I-A: GAMMA ROENTGENS PER MILLCURIE-HOUR DELIVERED AT VARIOUS DISTANCES FROM VARIOUS POINTS ALONG LINEAR COBALT 60 SOURCES

(1.0-cm. enclosed cobalt 60 capsule, diameter 3.2 mm.; lead plug at each end, 5.0 mm. length, 15.9 mm. diameter; filter 6.35 mm. wood and 2.2 mm. brass enclosing both wood and lead)

Cm. from Tube	Distance Along Tube Axis, in Centimeters						
	0.0	0.5	1.5	2.0	2.5	3.0	3.5
0			4.09	2.16	1.34	0.91	0.67
0.5							
1.0	10.36	8.59					
1.5	4.77	4.37	1.85	1.17	0.87	0.65	0.51
2.0	2.74	2.59	1.53	1.04	0.72	0.56	0.45
2.5	1.76	1.72	1.18	0.91	0.67	0.51	0.40
3.0	1.25	1.20	0.92	0.75	0.60	0.46	0.37
3.5	0.91	0.90	0.72	0.62	0.52	0.42	0.35
4.0	0.69	0.69					
5.0	0.45	0.45					
6.0	0.31	0.31					
7.0	0.23	0.22					
8.0	0.18	0.18					
9.0	0.14						
10.0	0.11						

TABLE I-B: GAMMA ROENTGENS PER MILLCURIE-HOUR DELIVERED AT VARIOUS DISTANCES FROM VARIOUS POINTS ALONG LINEAR COBALT 60 SOURCES

(1.0-cm. enclosed cobalt 60 capsule, diameter 3.2 mm.; filter 2.0 mm. brass)

Cm. from Tube	Distance Along Tube Axis: Centimeters from Center												
	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0
0.5	35.6	24.6	9.80	4.71	2.76	1.72	1.20	0.88	0.68	0.53	0.44	0.36	0.30
1.0	10.63	8.87	5.68	3.43	2.16	1.47	1.10	0.81	0.63	0.49	0.41	0.34	0.29
1.5	4.92	4.50	3.48	2.49	1.70	1.26	0.94	0.74	0.58	0.47	0.38	0.33	0.26
2.0	2.81	2.67	2.27	1.79	1.38	1.06	0.84	0.68	0.52	0.44	0.36	0.31	0.25
2.5	1.81	1.77	1.59	1.33	1.10	0.87	0.72	0.58	0.49	0.42	0.34	0.28	0.24
3.0	1.26	1.23	1.14	1.01	0.86	0.73	0.60	0.51	0.44	0.37	0.31	0.27	0.23
3.5	0.93	0.92	0.86	0.78	0.69	0.60	0.52	0.46	0.39	0.33	0.28	0.25	0.23
4.0	0.72	0.71	0.68	0.63	0.56	0.52	0.45	0.38	0.34	0.31	0.28	0.23	0.21
4.5	0.56	0.56	0.55	0.52	0.47	0.42	0.40	0.34	0.30	0.27	0.25	0.22	0.20
5.0	0.46	0.46	0.44	0.42	0.38	0.36	0.34	0.30	0.27	0.25	0.22	0.20	0.18
5.5	0.38	0.37	0.36	0.34	0.31	0.30	0.29	0.27	0.24	0.22	0.21	0.19	0.17
6.0	0.32	0.32	0.31	0.30	0.28	0.27	0.26	0.24	0.22	0.21	0.19	0.17	0.16
6.5	0.27	0.27	0.27	0.26	0.25	0.24	0.23	0.21	0.20	0.19	0.17	0.16	0.15
7.0	0.24	0.24	0.23	0.23	0.22	0.21	0.20	0.19	0.18	0.17	0.16	0.15	0.12
7.5	0.21	0.21	0.21	0.20	0.20	0.19	0.18	0.18	0.17	0.16	0.15	0.12	0.11
8.0	0.18	0.18	0.18	0.18	0.18	0.17	0.17	0.16	0.14	0.12	0.12	0.11	0.10

Point W is another point lying in the central ( $y = 0$ ) plane of the applicator, so the  $l$  distance for the colpostats is again zero. Since the distances are relatively great from these sources to the wall, the dosage rate is rather low, as is the dosage from the tandem sources. Only the right wall point is calculated (1,420 r) in this instance, but in many cases the two points are not equidistant—or sufficiently so—from the applicator, and both must be calculated.

Point A is likewise in the  $y = 0$  plane of the applicator, so that  $l$  for the colpostat is zero. All measurements from the tandem can be made from the anteroposterior view alone, since on the lateral view these points are superimposed on the tandem. This applies to the clip point C as well as to the wall point W. Point A is calculated to receive 6,900 r.

Upon completion of the computations as outlined, one has the total number of roentgens that will be delivered to the various points about the pelvis dur-

ing the time in which the bladder point is receiving 4,000 r in a period of gamma irradiation of eighty-four hours.

If point W by calculation is seen to receive less than the desired number of gamma roentgens during this time interval, the difference must be supplemented by external irradiation, the aim being to administer a total of gamma plus x-ray dosage of approximately 5,500 r (no less than 5,000; no more than 6,000).

#### SAMPLE APPLICATION OF SHORT METHOD OF CALCULATION, AS COMPARED WITH CALCULATION BY LONG METHOD

It is apparent by reference to the grid presentation of this sample case (Figure 4A) that the bladder is in the +1 position on the  $z$  axis, and the spread of the colpostats is represented by  $a = 2$  cm. The

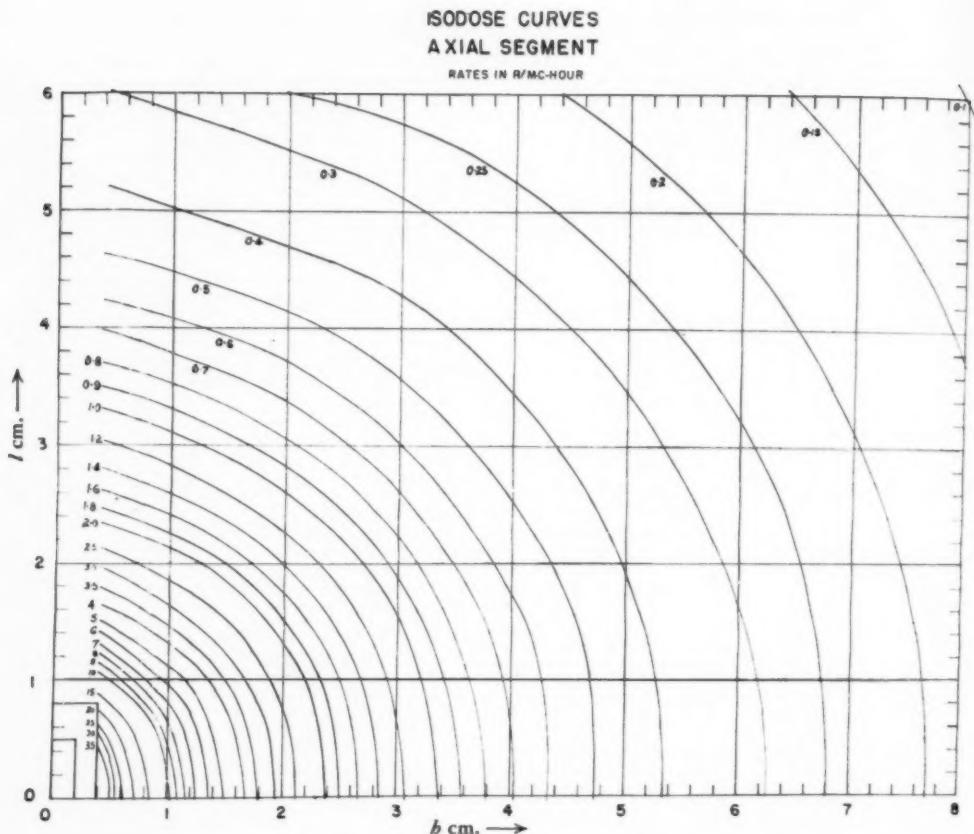


Fig. 6A. Isodose curves for the axial cobalt 60 segments used in the tandem.

TABLE II: EXPOSURE IN MILLICURIE-HOURS, S (SINGLE COLPOSTAT VALUE), THAT MUST BE APPLIED NOT TO EXCEED 4,000 GAMMA ROENTGENS TO BLADDER POINTS INDICATED AND TO ATTAIN DESIRED DOSAGE LEVELS

Axial Length	a. Cm. Spread (Colpostat Setting)	S Milliecurie-Hours for Various Critical Bladder Points			
		Bl <sub>1</sub> Limit	Bl <sub>0</sub> Limit	Bl <sub>+1</sub> Limit	Bl <sub>+2</sub> Limit
Short	1.75	1,100	1,030	1,100	945
	2.	1,100	1,070	1,100	955
	2.5	1,200	1,160	1,180	980
	3.	1,450	1,270	1,240	1,020
Medium	1.75	1,100	1,030	1,100	965
	2.	1,100	1,070	1,100	980
	2.5	1,230	1,160	1,180	1,010
	3.	1,500	1,270	1,240	1,050
Long	1.75	1,100	1,030	1,100	965
	2.	1,100	1,070	1,100	975
	2.5	1,230	1,160	1,180	1,010
	3.	1,500	1,270	1,240	1,050

long applicator is being employed. From Table II it is found that S mc-hr. must equal 1,100. Since S contains 13.1 mc, the application time is eighty-four hours.

This value agrees exactly with that calculated by the long method.

From Table III we note the following comparisons between the dose in gamma

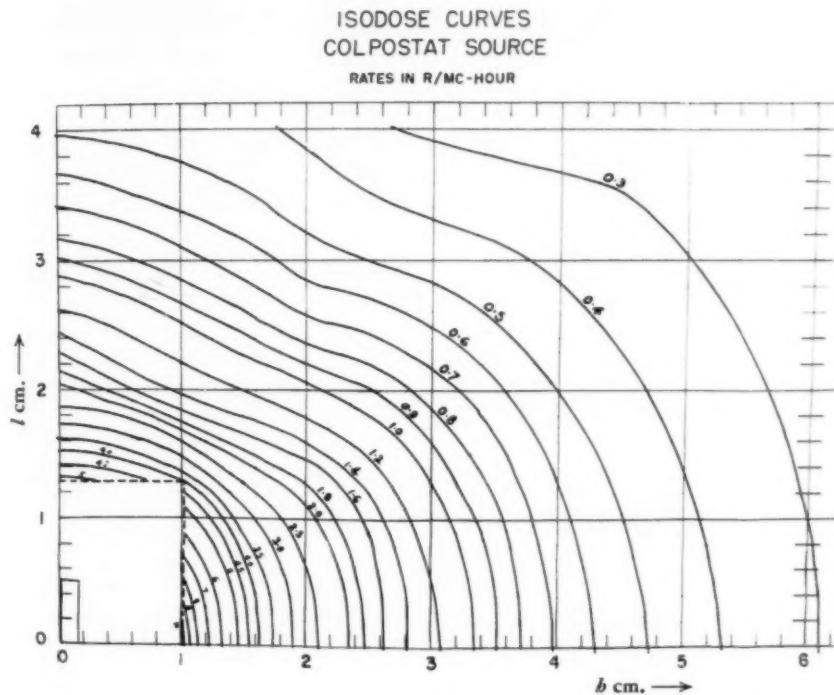


Fig. 6B. Isodose curves for the colpostat capsular sources shown in diagram in Fig. 3.

roentgens to the various points as determined by the long method as against the short method:

Pelvic Points	C <sub>1</sub>	A	C	W
Long method.....	8,100	6,900	11,260	1,420
Short method.....	7,900	7,000	11,200	1,450

In this example the slight discrepancy between the dosages indicated by the two methods is the result of the accumulated errors of interpolation in reading the isodose charts.

In the short method, we are using bladder measurements on the *z* axis which are closest to -1, 0, +1, +2, and intermediate distances between these "rounded-off" values are not considered. Also the bladder position on the *y* axis is fixed. This, therefore, gives us a calculation sufficient for clinical application, although not as exact as the actual measured value, in cases delivering 4,000 r to the bladder, although this dose is never exceeded; in some cases it may be as low as 3,500 r. In the above example, the 7,000 r to point

A was actually the limiting factor. If doses of 7,000 r or more to both point A and C<sub>1</sub> can be obtained with a dose to the bladder of less than 4,000 r, these points are used as the limiting factor in constructing Table II.

The differences between the short and long methods of calculation are of academic interest only, and in the usual application the short method may be employed. Where the application is asymmetrical or unusual in any way, the long method should be used.

#### SPECIAL CASE OF THE CERVICAL STUMP, WHERE TANDEM INSERTION IS NOT POSSIBLE AND COLPOSTATS MUST BE USED ALONE

When an intrauterine tandem cannot be inserted, it is important to note the limitations of the method in which colpostats are used alone. In these cases, Tod's point A cannot receive the previously indicated 7,000 r, while we still impose the previously described limita-

TABLE III: TOTAL GAMMA ROENTGENS DELIVERED TO VARIOUS PELVIC POINTS WHEN CRITICAL BLADDER POINTS ARE DOSED AS INDICATED IN TABLE II.

	Colpostat Setting, <i>a</i> . cm.	BL <sub>-1</sub> Limit					BL <sub>0</sub> Limit				
		BL <sub>-1</sub>	C <sub>1</sub>	A	C	W	BL <sub>0</sub>	C <sub>1</sub>	A	C	W
Short	1.75	3,480	9,600	7,000	15,200	1,360	4,000	9,000	6,600	14,200	1,280
	2.	3,300	8,100	7,000	11,420	1,420	4,000	7,800	6,800	11,000	1,360
	2.5	3,310	7,000	7,500	8,330	1,650	4,000	6,800	7,200	8,090	1,600
	3.	3,620	7,000	8,900	7,910	2,230	4,000	6,100	7,800	6,890	1,940
Medium	1.75	3,420	9,400	7,000	14,900	1,370	4,000	8,800	6,600	14,000	1,280
	2.	3,240	7,900	7,000	11,200	1,420	4,000	7,700	6,800	10,900	1,390
	2.5	3,330	7,000	7,700	8,330	1,720	4,000	6,600	7,200	7,850	1,620
	3.	3,680	7,000	9,200	7,910	2,310	4,000	5,900	7,800	6,670	1,950
Long	1.75	3,420	9,400	7,000	14,900	1,390	4,000	8,800	6,600	14,000	1,300
	2.	3,240	7,900	7,000	11,200	1,450	4,000	7,700	6,800	10,900	1,410
	2.5	3,330	7,000	7,700	8,330	1,740	4,000	6,600	7,200	7,850	1,640
	3.	3,680	7,000	9,200	7,910	2,310	4,000	5,900	7,800	6,670	1,950

	Colpostat Setting, <i>a</i> . cm.	BL <sub>+1</sub> Limit					BL <sub>+2</sub> Limit				
		BL <sub>+1</sub>	C <sub>1</sub>	A	C	W	BL <sub>+2</sub>	C <sub>1</sub>	A	C	W
Short	1.75	4,000	9,600	7,000	15,200	1,360	4,000	8,200	6,000	13,000	1,160
	2.	4,000	8,100	7,000	11,400	1,420	4,000	7,000	6,100	9,870	1,220
	2.5	4,000	6,900	7,400	8,210	1,630	4,000	5,700	6,100	6,780	1,340
	3.	4,000	6,000	7,600	6,780	1,910	4,000	4,900	6,200	5,540	1,560
Medium	1.75	3,870	9,400	7,000	14,900	1,370	4,000	8,300	6,200	13,200	1,210
	2.	3,800	7,900	7,000	11,200	1,420	4,000	7,000	6,200	9,940	1,260
	2.5	4,000	6,700	7,400	7,970	1,640	4,000	5,700	6,300	6,780	1,400
	3.	4,000	5,800	7,600	6,550	1,910	4,000	4,900	6,400	5,540	1,620
Long	1.75	3,880	9,400	7,000	14,900	1,390	4,000	8,300	6,100	13,200	1,230
	2.	3,820	7,900	7,000	11,200	1,450	4,000	7,000	6,200	9,940	1,280
	2.5	4,000	6,700	7,400	7,980	1,660	4,000	5,700	6,300	6,780	1,410
	3.	4,000	5,800	7,600	6,550	1,910	4,000	4,900	6,400	5,540	1,620

tions on bladder and rectum. Moreover, the dose delivered to the pelvic wall must of necessity be smaller, and hence greater supplementation is required by the external irradiation.

In Table IV, the dose delivered to the various points of interest in the pelvis is briefly summated for colpostat settings  $a = 1.75$ , 2, and 2.5 cm., respectively, when the bladder is not permitted to receive more than 4,000 r and a minimum dose of 7,000 r to C<sub>1</sub> is planned.

Since a dose to the vagina of 22,000 r is probably undesirable, we are virtually limited in our applications to the  $a = 2$  cm. or 1.75-cm. setting, the 2.0-cm. setting being the more desirable since the dose to the pelvic wall is greater in this case. Under these circumstances, the dose to point A is 2,500 r, which is too low for metastases in this region, even when one considers the supplementary dose obtained

from the external irradiation. We have on occasion employed a cylindrical needle implant in the cervical stump to bring this dosage up. A better expedient would probably be virtually to create a "short" type applicator by inserting a blunt additional needle in the center of the cervical stump, with a loading similar to that recommended for the short tandem, loading the T<sub>3</sub> position only, with the center of this source at 2.6 cm. on the z axis. This needle would need to have a minimum length of 3.3 cm., and would penetrate the upper end of the cervical stump but, by keeping the end of the needle blunt, penetration of other vital structures could probably be prevented. The danger of such a technic would be possible over-irradiation of a section of loop of small bowel which might rest against this heavily loaded segment with no distance between. Hence the distribution in a cylinder is preferable.

TABLE IV: DATA FOR COLPOSTAT USED ALONE (NO TANDEM POSSIBLE). EXPOSURES FOR MINIMUM DOSE OF 7,000 r AT POINT C<sub>1</sub>, WITH BLADDER RECEIVING 4,000 r MAXIMUM.

Colpostat Setting a. cm.	r/mc-hr. in S	S. mc-hr.	Time if S = 13.1 mc	Dose to Vagina	Dose to Pelvic Wall	Dose to C	Dose to C <sub>1</sub>	Dose to A
1.75	6.2	1,130	86	12,500	780	12,700	7,010	1,970
2.	4.8	1,460	111	15,500	1,070	11,400	7,000	2,510
2.5*	3.32	2,110	161	22,400*	1,750	9,300	7,000	3,400

\* Dose to vagina possibly excessive and hence possibly not desirable.

Transvaginal supplemental x-ray irradiation can also be employed in such cases.

#### SUMMARY

It is felt that for the purpose of comparison of the results of treatment of carcinoma of the cervix, treatment should be individualized for each patient. To this end, certain anatomical "fixed points" are defined, to which our treatment is directed.

A new applicator is described, together with the reasons necessitating its design.

A summary of the method of treatment of the four stages of spread of carcinoma of the cervix is included.

A typical clinical problem is evaluated, and a long and short method of dosage calculation are demonstrated.

University of Arkansas  
School of Medicine  
Little Rock, Ark.

#### REFERENCES

- BONEBRAKE, M., SHERMAN, A. I., TER-POGOSIAN, M., AND ARNESON, A. N.: Clinical Results Following Different Methods of Radium Application Used in the Treatment of Cervical Cancer from 1921 to 1947. Am. J. Roentgenol. **68**: 925-934, December 1952.
- BROWN, W. E., MESCHAN, I., KEREKES, E., AND SADLER, J. M.: Effect of Radiation on Metastatic Pelvic Lymph Node Involvement in Carcinoma of the Cervix. Am. J. Obst. & Gynec. **62**: 871-889, October 1951.
- CAMPBELL, L. A.: Carcinoma of the Cervix. An Applicator for Greater Parametrial Dosage. Am. J. Roentgenol. **57**: 697-702, June 1947.
- CUSCADEN, W. G., AND ODDIE, T. H.: A Dosage System of Cervical Cancer. M. J. Australia **2**: 1112-1121, Dec. 25, 1937.
- PORTMANN, U. V., editor: Clinical Therapeutic Radiology. New York, Thomas Nelson & Sons, 1950, pp. 161-392.
- FLETCHER, G. H.: Cervical Radium Applicators with Screening in the Direction of Bladder and Rectum. Radiology **60**: 77-84, January 1953.
- FLETCHER, G. H., SHALEK, R. J., WALL, J. A., AND BLOEDORN, F. G.: A Physical Approach to the Design of Applicators in Radium Therapy of Cancer of the Cervix Uteri. Am. J. Roentgenol. **68**: 935-947, December 1952.
- HENRIKSEN, E.: The Lymphatic Spread of Carcinoma of the Cervix and of the Body of the Uterus. A Study of 420 Necropsies. Am. J. Obst. & Gynec. **58**: 924-942, November 1949.
- MESCHAN, I., BROWN, W. E., AND REGNIER, G.: An Experimental Evaluation of Radical Pelvic Surgery Following Radical Radiation in Treatment of Carcinoma of the Cervix and a Microscopic Evaluation of the Surgical Tissues So Obtained. Mississippi Valley M. J. **74**: 162-167, November 1952.
- MORTON, D. G.: Pelvic Lymphadenectomy in the Treatment of Cervical Cancer. Am. J. Obst. & Gynec. **49**: 19-31, January 1945.
- TAUSSIG, F. J.: Iliac Lymphadenectomy for Group II Cancer of the Cervix. Technique and 5 Year Results in 175 Cases. Am. J. Obst. & Gynec. **45**: 733-748, May 1943.
- TOD, M. C.: The Optimum Dosage in the Treatment of Carcinoma of the Uterine Cervix by Radiation. Brit. J. Radiol. **14**: 23-29, January 1941.

(Para el sumario en español, véase la página 565)

# The Physical Aspects of the Utilization of the Tripartite Rigid Cobalt 60 Applicator for the Treatment of Carcinoma of the Cervix<sup>1</sup>

T. H. ODDIE, D.Sc., F. Inst. P.<sup>2</sup> and I. MESCHAN, M.D.<sup>3</sup>

THE BASIC physical considerations in the use of the cobalt 60 applicator for treatment of carcinoma of the cervix described in the preceding paper include:

(1) A provision of special dosimetry tables so that the gamma-roentgen contribution from each capsule of the applicator to any point in the pelvis may be summated.

(2) The projection of the applicator and its modifications on a three-axial geometric system, predicated certain fixed relationships between the applicator capsules and pelvic points which are to be representative of the desired radiation to the pelvis.

(3) The determination of the required radioactivity in each capsule so that the most desirable dosage to the various points may be obtained.

(4) The selection of the total capsular strength of each capsule so that the radiation time will be optimal and frequent manipulation of the contents of the capsule may be avoided.

(5) A method of adjustment of the cobalt 60 intensity within the capsules so that the desired total strengths can be obtained precisely, despite a relative irregularity in the cobalt sources initially.

(6) The provision of a short method of calculation when a symmetrical application of the applicator is obtained in a standard pelvis.

## UTILIZATION OF SPECIAL DOSIMETRY TABLES

If  $l$  is the distance of any point, in centimeters, in the axis of a linear radiant

source from the center of the source, and  $h$  is the perpendicular distance of any point from this axis, then special dosimetry tables may be provided whereby it is possible to indicate the roentgens per milli-curie-hour for many values of  $l$  and  $h$ , around these linear sources. Similarly, isodose curves may be provided which furnish comparable data.

Since there are two different types of capsular sources in the applicator under consideration, data have been calculated and presented for each type (Tables I-A and I-B and Fig. 6A and 6B of preceding paper). Correction has been made for self-absorption and oblique filtration and for special lead absorbers in the colpostat capsules. As previously indicated, the tandem capsules consist of cobalt 60 in cylinders of 1 cm. length, 1/8 inch in diameter, surrounded by walls of 2.0 mm. brass. The colpostat capsule is more complex, in order to derive the benefit of distance from the source and lead filtration toward bladder and rectum. This is shown in longitudinal section in Figure 3 of the preceding paper.

## REPRESENTATION OF RADIANT SOURCES AND PELVIC POINTS ON $x$ , $y$ , AND $z$ COORDINATES

Figure 5 of the preceding paper shows the rigid T-shaped arrangement which we have adopted, together with the critical points for calculation of dosage. The rectangular coordinates have their origin at the center of source  $T_1$ , the  $z$  axis coinciding with the axis of the uterine canal and the  $x$  and  $y$  axes lying in the coronal and sagittal planes, respectively.

<sup>1</sup> From the Department of Radiology, University of Arkansas School of Medicine, Little Rock, Ark., Research Series No. 996. Accepted for publication in May 1954.

With the assistance of grants-in-aid from the National Institute of Health, C-1866, the Damon Runyon Memorial Fund for Cancer Research, and the Atomic Energy Commission, Contract #AT-(40-1)-1078.

<sup>2</sup> Visiting Assistant Professor, Department of Radiology, University of Arkansas School of Medicine, on a Fullbright Fellowship.

<sup>3</sup> Professor and Head of Department of Radiology, University of Arkansas School of Medicine.

TABLE I: DOSAGE RATES AT VARIOUS POINTS IN THE PELVIS FOR 1 MC. COBALT 60 IN EACH SOURCE OF SPECIAL APPLICATOR

Source	Col-postat Setting, a cm.	Dosage Rates in r/Hour									
		C	C <sub>1</sub>	A	E	F	B <sub>L-1</sub>	B <sub>L0</sub>	B <sub>L+1</sub>	B <sub>L+2</sub>	
T <sub>1</sub>		21	21	0.83			2.30	2.8	1.60	1.10	0.29
T <sub>2</sub>		5.1	5.1	1.62			1.10	2.0	1.78	1.70	0.32
T <sub>3</sub>		1.50	1.50	2.75	1.61	2.71	0.63	1.00	1.28	1.74	0.33
T <sub>4</sub>		0.70	0.70	2.35	5.1	4.9	0.37	0.56	0.74	1.14	0.29
T <sub>5</sub>		0.39	0.39	1.25	10.0	3.0	0.24	0.34	0.46	0.66	0.25
S <sub>1</sub> + S <sub>2</sub>	1.75	11.2	6.2	1.74	0.80	1.12	2.10	2.24	1.46	1.30	0.69
S <sub>1</sub> + S <sub>2</sub>	2.0	7.8	4.8	1.72	0.77	1.08	1.94	2.10	1.40	1.26	0.73
S <sub>1</sub> + S <sub>2</sub>	2.5	4.41	3.32	1.61	0.72	1.01	1.70	1.81	1.30	1.14	0.83
S <sub>1</sub> + S <sub>2</sub>	3.0	2.91	2.30	1.49	0.67	0.92	1.44	1.51	1.14	0.98	0.98

The centers of the axial segments on the z axis are as follows:

T <sub>1</sub>	T <sub>2</sub>	T <sub>3</sub>	T <sub>4</sub>	T <sub>5</sub>
0	1.3	2.6	3.9	5.2 cm.

above the base line connecting the centers of S<sub>1</sub> and S<sub>2</sub>.

The colpostat sources S<sub>1</sub> and S<sub>2</sub> are arranged so that their axes parallel the y axis, and their centers are on the x axis at a cm. and -a cm., respectively.

Three-axial assemblies are considered: *long*, with all 5 axial sources; *medium*, with T<sub>5</sub> omitted; *short*, with T<sub>4</sub> and T<sub>5</sub> omitted. These provide for the varying lengths of uterine canal likely to be encountered. For each of these three assemblies, four values of colpostat spacing on the screw are arranged, namely, a = 1.75, 2.0, 2.5, and 3.0 cm., allowing for different degrees of expansion of the colpostat in the vaginal vault. These values correspond to an overall colpostat spread (outer margin to outer margin) of from 5.5 to 8.0 cm.

The points chosen for dosage calculation are:

#### —Figure 5 A and B—

C(cervix laterally)	x = 0.7	y = 0	z = 0
C <sub>1</sub> (cervix superiorly)	x = 0	y = 0.7	z = 0
W (lateral pelvic wall at site of obturator node)	x = 6	y = 0	z = 2
B <sub>L-1</sub> * (urinary bladder posteriorly at base)	x = 0	y = 2	z = -1
B <sub>L0</sub> * (urinary bladder posteriorly at base)	x = 0	y = 2	z = 0

B<sub>L+1</sub>\* (urinary bladder posteriorly at base)      x = 0      y = 2.5      z = 1

B<sub>L+2</sub>\* (urinary bladder posteriorly at base)      x = 0      y = 2.5      z = 2

A (Tod's point A converted to our axial system)      x = 2      y = 0      z = 3

F (uterine wall)      x = 1.5      y = 0      z = 4

E (uterine fundus)      x = 1      y = 0      z = 5

R Rectal point also found on the radiograph. The calculations for the point B1 should also suffice here.

\* The designation of the y values for these bladder points is an arbitrary index, since we have found that, when sodium iodide is placed in the bladder and roentgenograms are taken, the bladder virtually wraps itself around the uterus and applicator.

#### CALCULATION OF THE DISTRIBUTION OF RADIOACTIVITY TO BE USED WITHIN THE APPLICATOR

The gamma dosage requirements which have been specified may be represented as:

D<sub>C</sub>: 7,000 r minimum

D<sub>B1</sub>: 7,000 r minimum

D<sub>B2</sub>: 4,000 r maximum

D<sub>w</sub>: As high as possible

where D<sub>C</sub> is the gamma dose at point C, D<sub>B1</sub> the dose to the bladder point, and so on.<sup>4</sup>

Table I presents the calculated individual dosage rates at the various pelvic

<sup>4</sup> D<sub>B1</sub> represents the dose at any of four bladder points considered on the z axis: -1, 0, 1, 2. In the y axis (sagittal plane) these points are at 2.0, 2.5, and 2.5 cm. respectively. All four of these points are at 0 on the x axis.

TABLE II: COMBINED DOSAGE RATES AND RATIOS OF RATES FOR STRENGTH S = 1 MC IN THE SPECIAL RIGID APPLICATOR

Assembly	Colpostat Setting, a cm.	Dosage Rates in r/Hour						Ratio of Rates			
		C	C <sub>1</sub>	A	D	E	W	C/C <sub>1</sub>	F/A	E/A	W/C <sub>1</sub>
Short	1.75	13.8	8.7	6.4	5.7	3.5	1.24	1.58	0.89	0.55	0.142
	2	10.3	7.3	6.3	5.6	3.5	1.28	1.41			0.175
	2.5	6.9	5.8	6.2	5.6	3.4	1.38	1.19			0.236
	3	5.4	4.8	6.1	5.5	3.4	1.53	1.13			0.318
Medium	1.75	13.6	8.6	6.4	6.4	4.5	1.25	1.59	1.0	0.71	0.146
	2	10.2	7.2	6.3	6.3	4.5	1.29	1.42			0.180
	2.5	6.8	5.7	6.2	6.2	4.4	1.39	1.19			0.245
	3	5.3	4.7	6.1	6.2	4.4	1.54	1.13			0.330
Long	1.75	13.6	8.6	6.4	6.4	6.4	1.27	1.59	1.0	1.0	0.148
	2	10.2	7.2	6.3	6.4	6.4	1.31	1.42			0.183
	2.5	6.8	5.7	6.2	6.3	6.4	1.41	1.19			0.248
	3	5.3	4.7	6.1	6.2	6.3	1.56	1.13			0.330

points when 1 millicurie of cobalt 60 is contained in each source indicated, and when the colpostat setting is as shown.

From the values given in Table I, it is seen that the dose to C<sub>1</sub> (D<sub>C<sub>1</sub></sub>) is always less than D<sub>C</sub> so that the primary need is to make:

$$D_{Bl}/D_{C_1} \text{ not greater than } 4/7 \quad (1)$$

A secondary objective is to provide an adequate relative dose at point A. If we set this at 7,000 r<sup>6</sup>, in conformity with Tod and Meredith's (16) recommendation when x-rays are to be given as well, we have:

$$D_{C_1}D_A = 1 \quad (2)$$

Now source T<sub>1</sub> alone contributes (Table I) a ratio D<sub>C<sub>1</sub></sub>/D<sub>A</sub> = 25 and T<sub>2</sub> a ratio of 3.2, while T<sub>3</sub>, T<sub>4</sub>, and T<sub>5</sub> each gives a ratio less than 1, and the colpostat S<sub>1</sub> + S<sub>2</sub> gives ratios between 1.5 and 3.6. The combined effect can thus be made to yield a ratio 1 by using (S<sub>1</sub> + S<sub>2</sub>) and any or all of T<sub>3</sub>, T<sub>4</sub>, T<sub>5</sub>. It is therefore better to make T<sub>1</sub> and T<sub>2</sub> each zero, thus conserving as much activity as possible for (S<sub>1</sub> + S<sub>2</sub>) to make the dose at W the best possible value.

Considering now a "short" assembly of sources S<sub>1</sub>, S<sub>2</sub>, and T<sub>3</sub> only, with the most likely colpostat setting a = 2 cm., we find Bl<sub>+2</sub> is the worst bladder point

<sup>6</sup> 6,500-7,000 when x-rays are to be used (3,000 r at point W); 8,000 r when no x-rays are to be used.

and Equation 1 can be satisfied by taking a ratio of radioactive source strengths

$$T_3/S = 1.68 \quad (3)$$

where

$$S_1 = S_2 = S.$$

This ratio will not quite meet Equation 2, but it is the best we can do if we decide to lower the dose at point A rather than at point C<sub>1</sub>.

Next, proceeding to a "medium" assembly with source T<sub>4</sub> added, we can adjust the dose at a further point F to equal that at A. It is found that we need

$$\begin{aligned} T_3/S &= 1.44 \\ T_4/S &= 0.28 \end{aligned} \quad (4)$$

Similarly for a "long" assembly, with T<sub>5</sub> added as well and dosage at a further point E made equal to that at A,

$$\begin{aligned} T_3/S &= 1.47 \\ T_4/S &= 0.95 \\ T_5/S &= 0.27 \end{aligned} \quad (5)$$

These ratios are not very critical and have therefore been further modified for convenience as follows:

Assembly	T <sub>3</sub> /S	T <sub>4</sub> /S	T <sub>5</sub> /S
Short	1.68		
Medium	1.45	0.27	
Long	1.45	0.12	0.27

With these ratios and the individual

TABLE III: DOSE AT VAGINAL POINTS  $V_1$  AND  $V_2$  FOR APPLICATORS AS SHOWN IN TABLES II AND III OF PRECEDING PAPER

Point	Short Applicator				Medium Applicator				Long Applicator			
	$a = 3 \text{ cm.}^*$		$a = 2.5 \text{ cm.}$		$a = 3 \text{ cm.}^*$		$a = 2.5 \text{ cm.}$		$a = 3 \text{ cm.}^*$		$a = 2.5 \text{ cm.}$	
	max. mc- hr. S	max. hr. r										
$V_1$	1,450	18,000	1,200	14,900	1,500	18,600	1,230	15,300	1,500	18,600	1,230	15,300
$V_2$	1,450	16,800	1,200	13,900	1,500	17,300	1,230	14,200	1,500	17,300	1,230	14,200

\*  $a = 3 \text{ cm.}$  would be the worst possible case and would not be recommended for use in any patient.  $a = 2.5 \text{ cm.}$  and 2 cm. are recommended. (Values for  $a = 2$  are approximately 8 per cent less than  $a = 2.5 \text{ cm.}$ )

dose rates of Table I, the combined dose rates for strength  $S = 1 \text{ mc}$  have been calculated for the selected points and are given in Table II. Selection of the actual exposure in terms of an  $S$  value of so many millicurie-hours is then dependent on the most critical position of the bladder (or rectum). In Table II of the preceding paper are indicated the millicurie-hours for the  $S$  source which will deliver no more than 4,000 gamma roentgens to the critical bladder point for each of the four bladder points selected while still giving as nearly as possible the desired dosages to the other points. When these  $S$  values are used, Table III of the preceding paper indicates the doses in gamma roentgens that are delivered to points  $C_1$ ,  $C$ ,  $A$ , and  $W$ .

Point  $Bl_{+2}$  is the worst position for the bladder to occupy, of all four considered;  $Bl_0$  is the next worst, followed by  $Bl_{+1}$ . Finally,  $Bl_{-1}$ , is the best.

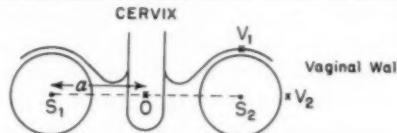
It is also noted that the dose to the cervix under these circumstances is frequently low with the 3.0-cm. spread of the colpostats, and this spread should be avoided if possible. Even the 2.5-cm. spread will not always give desirable dose levels to the cervix. Hence, wherever possible, a more desirable distribution of dose is obtained with the smaller degrees of spread of the colpostats. With these smaller degrees of spread, the wall value, point  $W$ , will be low on occasion, but this can be compensated by additional x-ray dosage

from external ports. In general, the 2-cm. spread of the colpostats, if possible, is probably the most advantageous from every standpoint.

It is noteworthy that if one employs the above tables, a critical dose to the bladder and rectum of 4,000 gamma roentgens is never exceeded. This dose to the bladder must merely be regarded as an index of dosage probably within the tolerance range of patients, on an empirical basis. Actually, the bladder dose is extremely difficult to predict, since the bladder virtually wraps itself around the applicator, as cystograms will show.

It is probably also of some practical importance to know the dosage levels attained in the vaginal mucosa immediately adjoining the colpostats when one follows a system of dosage such as has been advocated above. For this purpose, we have calculated the dosage delivered to two vaginal points within and adjoining the vaginal lateral fornix as indicated in the diagram accompanying Table III. One of these points,  $V_1$ , is opposite the center of the colpostat source,  $S$ , where the colpostat makes contact with the vaginal fornix ( $x = a$ ,  $y = 0$ ,  $z = 1$ ).  $V_2$  is a vaginal point 90 degrees around the colpostat from  $V_1$  ( $x = a + 1$ ,  $y = 0$ ,  $z = 0$ ).

The dosage delivered to these points has been calculated in each instance for the maximum number of millicurie-hours for the  $S$  source, for each applicator type,



short, medium, and long, and for distances  $a = 3$ , and  $a = 2.5$ . Since  $a = 3$  is not recommended, our prime interest is in  $a = 2.5$  (and  $a = 2.0$ , which is approximately 8 per cent less than the  $a = 2.5$  values). It will be noted that the dosage delivered to these vaginal points is on the order of 14,000 to 15,000 r maximum—a considerable improvement over the enormous dosage levels obtained with the Ernst applicator (frequently in excess of 25,000 r).

Also, it is important to irradiate these points adequately, since tumor extension not infrequently involves these areas of the vagina. However, if significant vaginal extension is encountered, special additional irradiation to these tumor-bearing areas is recommended beyond that routinely applied.

#### SELECTION OF TOTAL RADIOACTIVE STRENGTH IN APPLICATOR

From Table II of the preceding paper it is evident that  $S$  varies from 345 to 1,500 millicurie-hours; it is practically convenient to choose the amount of cobalt 60 upon the first loading, to give exposure times of between three and five days. Thus, if  $S$  is made 13.1 mc, the exposure time will be between 72 and 114 hours, usually eighty-four hours. The individual sources work out as in Table IV, using the relative strengths derived earlier.

TABLE IV: CONVENIENT SOURCE STRENGTHS IN MILLICURIES WHEN LOADED\*

Assembly	$S_1$	$S_2$	$T_3$	$T_4$	$T_5$	Total
Short	13.1	13.1	22.0			48.2
Medium	13.1	13.1	19.0	3.5		48.7
Long	13.1	13.1	19.0	1.57	3.5	50.27

\*  $T_1$  and  $T_2$  contain no activity.

After radioactive decay for about 3.6 years, the exposure times will have increased to the range 115 to 192 hours, and it will then probably be necessary to reload the applicator.

It will be noticed that the same colpostat sources are needed throughout, while  $T_4$  for the medium assembly could be moved

to become  $T_5$  for the long assembly if desired.

Actually, in a busy clinic such as ours, we have found that it is desirable to keep two of each of three types of applicator on hand and intact, so that a minimum of handling and exposure is required. The cobalt 60 is obtained quite cheaply, and the six applicators are relatively inexpensive.

#### ADJUSTING MINOR VARIATIONS IN COBALT 60 CAPSULES

To load the applicators with cobalt 60 sources of the desired strengths, it will usually be necessary to provide some means of adjustment, because sources obtained from the pile irradiation of cobalt metal will be subject to rather wide variations from their nominal radioactive content.

We have effected this adjustment by building up each 1-cm. unit for the applicator from irradiated and dummy cobalt beads, of external diameter 3.2 mm. and internal diameter 1.2 mm. The irradiated beads are 2.4 mm. long, so that two, three, or four may be selected for a source, depending on their departure from nominal strength. When two or three beads are used, one or two dummy spacers are added to bring the total length to 10 mm. Then a final strength adjustment is made with a piece of irradiated cobalt wire 1 mm. in diameter and up to 10 mm. long, pushed down the axial hole in the assembled beads. In this way, we can cope with variations in the normal strength of the sources of + or -30 per cent.

#### PROVISION OF A SHORT METHOD OF CALCULATION WHEN A SYMMETRICAL APPLICATION IS OBTAINED IN A STANDARD PELVIS

If the applicator is sewed to the cervix, if one may make certain of this close relationship radiographically, and if the position of the applicator is symmetrical with respect to the two pelvic walls, there are virtually only two variables on the 3-axial system: (a) the degree of separa-

tion of the colpostats; (b) the relationship of the applicator to the bladder.

The separation of the colpostats may be regulated by the "calibrated spreaders," which are an integral part of the fixed applicator system. Four spreaders are provided to give a total spread (outer diameter of  $S_1$  to outer diameter of  $S_2$ ) of 5.5 cm., 6.0 cm., 7.0 cm., and 8.0 cm. ( $a = 1.75, 2.0, 2.5$ , and  $3.0$  cm., respectively).

The only remaining variable is the relationship of the applicator to the bladder. If this compares closely on a lateral radiograph to one of the four bladder points indicated ( $Bl_{-1}$ ,  $Bl_0$ ,  $Bl_{+1}$ , and  $Bl_{+2}$ ), it is possible to tabulate the ideal dose necessary for each of these four points for each standard spread of the colpostats in terms of any one or all of the capsules.

This has been done, with the dose for  $S$  as a determining medium (Table II of preceding paper), and when this dose is used, it is possible to tabulate the roentgen contribution to the various pelvic points (Table III of preceding paper).

The modus operandi of this "short" method is as follows:

(1) It is first established that the application to the cervix is good and the position of the applicator symmetrical with respect to the pelvis.

(2) The "spread" of the colpostats is noted, by use of the standard spreader.

(3) On the lateral radiograph, the bladder point is determined and interpreted with respect to the  $z$  axis as  $Bl_{-1}$ ,  $Bl_0$ ,  $Bl_{+1}$ , or  $Bl_{+2}$ .

(4) In the appropriate columns of Table II of the preceding paper, for the

spreader value  $a$  and the bladder point  $Bl$ , the total number of millicurie-hours which the colpostat may be applied is obtained.

(5) When the number of millicuries contained in  $S$  is known, the number of hours of application is readily obtained.

(6) From Table III of the preceding paper the gamma roentgen contribution to each pelvic point is indicated when the above dosage for  $S$  is utilized.

It should be emphasized that this "short" method is actually applicable only for a symmetrical application. Otherwise, the longer method of calculation, as described in the previous paper, must be used.

#### GENERAL SUMMARY

By means of special dosimetry tables and radiographs corrected for magnification, it is possible to obtain the gamma roentgen contribution to any point in the pelvis.

By predicated certain fixed relationships between a specially designed rigid applicator and these pelvic points, an ideal distribution of radioactivity in each capsule of this applicator has been determined. Optimal capsular strength for each capsule is indicated and a method of adjusting the cobalt 60 intensity within the capsules to these optimal strengths is described.

For a symmetrical application in an average pelvis, a short method of calculating the dosage delivered to these pelvic points is derived and presented.

University of Arkansas  
Medical School  
Little Rock, Ark.

#### SUMARIO

Método de Dosimetría para el Carcinoma del Cuello Uterino que Utiliza una Modificación de la Técnica de Mánchester con Cobalto-60

(Véase la página 546)

Describen los AA. su método de tratamiento del carcinoma del cuello uterino con la aplicación intracavitaria de focos de cobalto-60 y roentgenoterapia externa. Para la irradiación intracavitaria han el-

aborado un nuevo aplicador rígido que posee las ventajas de los ovoides de Mánchester y lleva además un tandem fijo en relación con los focos colpostáticos.

Enuméranse seis puntos anatómicos de

la pelvis hacia los cuales se encarrila el tratamiento, a decir:

Puntos C y C<sub>1</sub>, lateral y superior, respectivamente, al centro del orificio externo.

Punto A de Tod, 2.0 cm. más arriba del nivel del fórnix lateral y 2.0 cm. al lado del eje uterino central.

Punto W, 6 cm. al lado del eje uterino central y 2 cm. más arriba del nivel del fórnix lateral. Este punto indica la pared lateral de la pelvis, donde suele encontrarse el ganglio linfático obturador.

Punto Bl, punto en la pared posterior de la base de la vejiga urinaria, que varía en cada enferma.

Punto R, el punto en el recto que queda

más cercano al aplicador intracavitario.

Se consignan las dosis que los AA. tratan de obtener de los focos intracavitarios y externos en cada uno de dichos puntos, bosquejándose el tratamiento para los varios períodos. En el Período IV, ordinariamente todo lo que puede utilizarse es roentgenoterapia externa paliativa. En todos los demás períodos, se combinan la irradiación intracavitaria y la irradiación roentgen externa.

Preséntase un caso como ejemplo con cálculos de la dosis, y se exponen los métodos largo y corto para hacer los mismos. El método abreviado es aplicable a los casos corrientes.

#### SUMARIO

(Véase la página 560)

#### Los Aspectos Físicos de la Utilización del Aplicador Rígido de Cobalto-60 para el Tratamiento del Cáncer del Cuello Uterino

Discútense ciertas fundamentales consideraciones físicas en el empleo del aplicador de cobalto-60 de los AA. (véase el trabajo anterior).

Por medio de tablas especiales de dosimetría y radiografías corregidas en cuanto a ampliación, es posible obtener el aporte en roentgens de rayos gamma a cualquier punto de la pelvis.

Predicando ciertas relaciones fijas entre un aplicador rígido diseñado *ad hoc* y esos

puntos pélvicos, se ha determinado una distribución ideal de radioactividad en cada cápsula de este aplicador. Se indica la concentración capsular óptima y se describe un método para ajustar la intensidad intracapsular del cobalto-60 a esas concentraciones óptimas.

Para la aplicación simétrica en la mayoría de las pelvis, se presenta un método abreviado para calcular la dosis entregada a dichos puntos de la pelvis.



## The Use of Radioiodine in the Study of Thyroid Disorders<sup>1</sup>

J. P. NICHOLSON, B.A., B.Sc., C. W. WILSON, M.Sc., Ph.D., F.Inst.P., K. A. NEWTON, M.R.C.P., D.M.R.T., and  
R. G. C. MacLAREN, F.R.C.S., D.M.R.T.

MANY PAPERS describing techniques for the use of radioiodine as a tracer substance have appeared, notably those of Ansell and Rotblat (1948), Dobyns, Skanse, and Maloof (1949), Pochin (1950), Cassen, Curtis, Reed, and Libby (1951), Bauer, Goodwin, Libby, and Cassen (1952, 1953). The present communication describes procedures which have been carried out at Westminster Hospital (London) in the study of a variety of thyroid disorders.

Ansell and Rotblat in their investigations into the uptake of radioiodine by intrathoracic goiters used a heavily shielded counter attached to a mobile x-ray tube stand and provided with means for scanning the neck and chest. Dobyns *et al.* employed a similar method. In each case the collimating shield of the counter was placed at known positions on the patient and readings were taken. The scintigram was introduced in 1951 by Cassen, Curtis, Reed, and Libby. Although this latter technique has produced interesting results, it involves the use of somewhat complex equipment, which may not readily be available in a medical laboratory. For this reason, we have endeavored to evolve a method which would give a quantitative result with the simplest of apparatus. We have used a GM tube in our experiments, but the procedure could easily be adapted for use with a scintillation counter.

We have not, except in one case, attempted any accurate assessment of percentage uptake of radioiodine but have concentrated on determining its spatial distribution in areas of interest.

### TECHNIQUE

The first step in the investigation consists in making a plaster cast of the thyroid region and any other areas of interest.

Several anatomical landmarks are painted on the cast and the surface is ruled into 2-cm. squares. Radioiodine is then given by mouth. The amount varies, depending on the patient's age and on the nature of the thyroid disorder under investigation, but is usually of the order of 100 microcuries.

After an interval of about three hours, the plaster cast is again fitted to the patient and count-rate readings are taken at each 2-cm. interval. The Geiger counter used is a type GM4, collimated with a lead shield 1 cm. thick and having an aperture of 1 cm. diameter (Nicholson, Wilson, and Newton, 1954). The readings are recorded on a count-rate meter, type 40A (Messrs. Panax Ltd., London).

From graphs of the observed count rates, the coordinates of a point having any particular count rate can be deduced. Iso-count curves are then drawn on the cast. It has been shown (Nicholson *et al.*) that, for the experimental arrangements described, the geometrical edge of the iodine-concentrating area coincides very roughly with the 50 per cent iso-count curve. In this way the distribution of the radioiodine lying beneath the cast can be determined relative to the anatomical landmarks.

We have not found it necessary to put the patients on an iodine-free diet for some time prior to the test. The method is not a quantitative one except in the estimation of dose delivered to an isolated mass, as described below, and cannot be used, for instance, in the investigation of thyrotoxicosis.

### APPLICATIONS

*The Normal Thyroid Picture:* Tracer studies performed on a number of nor-

<sup>1</sup> From the Physics Department (J. P. N. and C. W. W.) and the Radiotherapy Department (K. A. N. and R. G. C. MacL.), Westminster Hospital, London, England. Accepted for publication in March 1954.

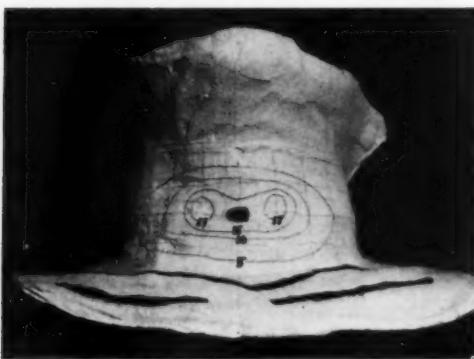


Fig. 1. The normal thyroid picture. Thyroid prominence and clavicles are shown.

mal subjects have given almost identical iso-count contours. Figure 1 shows the iso-count curves drawn on the cast of a normal patient. The two centres of high concentration corresponding to the two lobes of the thyroid and the symmetry of the curves about the vertical centre line are clearly shown.

*After Partial or Complete Thyroidectomy:* A tracer test on a patient<sup>2</sup> who had undergone a left hemithyroidectomy for a potentially malignant adenoma but had received no postoperative irradiation is illustrated in Figure 2. It showed a normally functioning right lobe with no evidence of pick-up on the left.

In another patient,<sup>2</sup> with a moderately well differentiated papillary carcinoma, in whom thyroidectomy was complete except for a small portion of the superior pole of the left lobe, a course of radium teletherapy was given for a total tumor dose of 6,400 r over a period of seven weeks. Six months after completion of irradiation a tracer dose of 300 microcuries of radioiodine was given, and the thyroid remnant was found to possess good concentrating power in spite of the heavy irradiation (Fig. 3). Administration of thyroid extract was thus shown to be unnecessary.

*Investigation of an Isolated Mass:* Caution must be observed in the interpretation of radioiodine uptake studies of an isolated mass. Evidence of uptake indicates that

the mass contains functioning thyroid tissue, but in the absence of uptake the result is equivocal. Loss of function may be the result of thyroid disease or possibly of a lesion unassociated with the thyroid. A high proportion of thyroid carcinomas show no pick-up (Paterson, 1950).



Fig. 2. Curves obtained after left hemithyroidectomy. The right lobe appears to be functioning normally.

Figure 4 shows evidence of function in an isolated mass. The patient,<sup>3</sup> a female, had undergone subtotal thyroidectomy at the age of four for thyrotoxicosis. At thirteen, coincident with the beginning of puberty, a swelling appeared near the left upper border of the thyroid cartilage. The patient was given 50 microcuries of radioiodine by mouth, and the readings indicated the presence of thyroid function, as shown in the figure. Two years later the mass had doubled in size and a second tracer test showed the uptake to be confined to the area of the swelling.

*Total Thyroidectomy and Skeletal Metastases:* The following case illustrates the advantages of the tracer technique in the presence of skeletal metastases following thyroidectomy.

A woman of sixty-eight<sup>4</sup> gave a history of an enlarged thyroid for fifty years, without symptoms or increase in size. In 1947 she sustained a fracture of

<sup>2</sup> Patient of Sir Stanford Cade.

<sup>3</sup> Patient of Mr. G. H. Macnab.

<sup>4</sup> Patient of Mr. T. M. Prossor.

the fifth right rib, and three years later a swelling appeared at this site. Biopsy showed well differentiated secondary thyroid carcinoma. In March 1951, the patient suffered a fracture of the right humerus and a second metastasis was demonstrated at the fracture site. Total thyroidectomy was performed in July 1951 and an anaplastic carcinoma with a well demarcated edge and containing fibrous tissue was

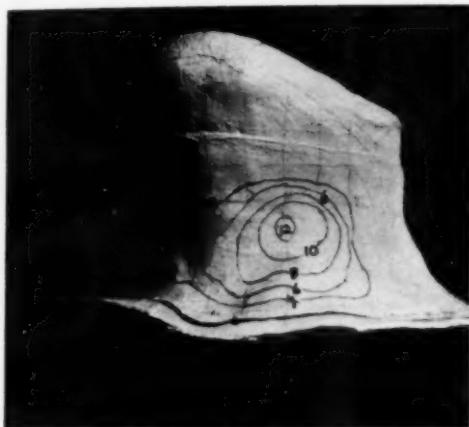


Fig. 3. Curves obtained after complete thyroidectomy, except for superior pole of the left lobe, followed by irradiation.

found. Two months later a tracer dose of radioiodine, 1,900 microcuries, was given and the uptake in the neck was very small.

Plaster casts were prepared of the lower right arm and the chest wall overlying the right fifth rib. Detailed readings were taken over the surface of the casts and iso-count curves were drawn, showing that the uptake in the lower end of the humerus was much higher than in the rib.

In order to obtain some information as to the absolute uptake in the arm, a Bakelite cylinder of approximately the same shape and size as the metastasis in the humerus (as measured on the radiographs) was made and filled with a radioiodine solution of known concentration. This cylinder was placed in the arm cast in the position occupied by the metastasis and the remaining space was packed with rice-sodium bicarbonate bolus material (Spiers, 1943). Count rates were obtained over the cast under these conditions and the shape of the iso-count curves derived was found to correspond reasonably well with those obtained by measurement on the patient. From the ratio of the average count-rates in the two casts, the concentration of iodine in the arm could be calculated. Further observations showed that the uptake in the rib was about one-tenth of that in the arm.

The uptake in the skeletal metastases having proved satisfactory, a therapeutic dose of radioiodine (150 millicuries) was given one week after



Fig. 4. Iodine uptake in an isolated mass.

the tracer test. Within twenty-four hours the patient complained of pain in the right arm and count-rate readings showed that approximately 70 millicuries of the administered isotope were present in the humerus. Readings were continued over a long period to determine the biological half-life of the radioiodine and hence (Marinelli, Quimby, and Hine, 1948) the total dose delivered to the metastasis. This was calculated to be of the order of 100,000 rep. Although this figure is subject to a considerable margin of error, it is of interest in showing the order of magnitude of the very large dose delivered. The dose delivered to the metastasis in the rib was of the order of 10,000 rep. The excretion curve and the decay curve of activity in the arm showed that almost all the radioiodine in the body was held fixed in the skeletal metastases.

A series of radiographs showed progressively increasing calcification of the lesion in the humerus, together with some change in the right rib. In February 1952, another tracer test indicated that there was still some pick-up in the right humerus, though only about one-tenth of that previously observed. There was no uptake in the right rib, but it was noticed that the readings near the right shoulder were some four times higher than over the left shoulder. A radiograph showed a small area of periosteal elevation in the outer third of the right clavicle.

A second therapeutic dose of 150 millicuries of radioiodine was given in March 1952. Since then the patient has continued well and can now (February 1955) use her arm perfectly.

**Lingual Thyroid:** In a case of lingual thyroid<sup>5</sup>, proved by biopsy, a tracer test showed no iodine concentration below the thyrohyoid membrane (Fig. 5). Since the mass in the tongue was thus apparently the only functioning thyroid tissue present,

<sup>5</sup> Patient of Sir Stanford Cade.



Fig. 5. Iso-count curves indicating the presence of a lingual thyroid.

its surgical removal was considered contraindicated.

*Retrosternal Thyroid:* The demonstration of a retrosternal thyroid is illustrated in Figure 6. In this case<sup>6</sup> a mass had been discovered below the upper end of the sternum. There was no evidence of thyrotoxicosis, and clinical examination showed moderate enlargement of both thyroid lobes. An iodine tracer test was undertaken to determine the nature of the substernal mass, and the 50 per cent iso-count curve was found to cross the sternum 2 inches below the suprasternal notch, giving clear evidence of the existence of substernal thyroid.

#### CONCLUSIONS

The advantages of the technique described here are several. Standard commercial apparatus is used, the only necessary addition being the collimating device for the counter tube. The patient suffers little inconvenience, attending in the morning to have the plaster cast made and to be given the radioiodine drink. The afternoon attendance, when the readings are taken, consumes about half an hour. Subsequent analysis of the results and the drawing of the iso-count curves involve about one hour of work.

From the clinical point of view, the

method offers a rapid means of investigating the iodine uptake in a particular region, though, as mentioned above, care must be taken in assessing cases in which there is no evidence of radioiodine uptake. Valuable guidance as to future treatment can be obtained by the administration of a



Fig. 6. Iso-count curves showing the presence of retrosternal thyroid tissue.

tracer dose to a thyroid carcinoma. It can be estimated whether or not the uptake in the gland or secondary tumors is sufficient to warrant a therapeutic dose of the isotope.

As the GM tube is held directly in contact with the cast while the readings are taken and the cast is in intimate contact with the patient, no unpredictable movement of the patient with respect to the measuring apparatus is possible. The iso-count curves are transferred to the cast on which the anatomical landmarks are painted, and this can be studied after the patient has left and can be used for demonstration purposes.

**ACKNOWLEDGMENTS:** The authors wish to acknowledge the financial assistance given by the British Empire Cancer Campaign to the departments in which this work was done. They are also grateful for the permission given by Sir Stanford Cade, K.B.E., C.B., F.R.C.S., M.R.C.P., G. H. Macnab, F.R.C.S., T. M. Prossor, B.Sc., F.R.C.S., D.M.R., and R. D. Tonkin, M.D., M.R.C.P., for the cases cited and for referring to them other clinical material upon which they have not commented in detail.

<sup>6</sup> Patient of Dr. R. D. Tonkin.

## REFERENCES

1. ANSELL, G., AND ROTBLAT, J.: Radioactive Iodine as a Diagnostic Aid for Intrathoracic Goiter. *Brit. J. Radiol.* **21**: 552-558, November 1948.
2. BAUER, F. K., GOODWIN, W. E., LIBBY, R. L., AND CASSEN, B.: Visual Delineation of Thyroid Glands in Vivo. *J. Lab. & Clin. Med.* **39**: 153-158, January 1952.
3. BAUER, F. K., GOODWIN, W. E., LIBBY, R. L., AND CASSEN, B.: The Diagnosis of Morphologic Abnormalities of the Human Thyroid Gland By Means of  $I^{131}$ . *Radiology* **61**: 935-938, December 1953.
4. CASSEN, B., CURTIS, L., REED, C., AND LIBBY, R. L.: Instrumentation for  $I^{131}$  Use in Medical Studies. *Nucleonics* **9**: 46-50, August 1951.
5. DOBYNS, B. M., SKANSE, B., AND MALOOF, F.: A Method for the Preoperative Estimation of Function in Thyroid Tumors; Its Significance in Diagnosis and Treatment. *J. Clin. Endocrinol.* **9**: 1171-1184, November 1949.
6. MARINELLI, L. D., QUIMBY, E. H., AND HINE, G. J.: Dosage Determination with Radioactive Iso-
- topes. II. Practical Considerations in Therapy and Protection. *Am. J. Roentgenol.* **59**: 260-280, February 1948.
7. NICHOLSON, J. P., WILSON, C. W., AND NEWTON, K. A.: The Distribution of Radioiodine Observed in Thyroid Disease by Means of Geiger Counters—Its Determination and Significance. *Am. J. Roentgenol.* **72**: 849-856, November 1954.
8. PATERSON, R.: Symposium on Diagnostic and Therapeutic Uses of Radioactive Isotopes. V. The Treatment of Thyroid Carcinoma by Radioiodine. *Brit. J. Radiol.* **23**: 553-556, September 1950.
9. POCHIN, E. E.: Investigation of Thyroid Function and Disease with Radioactive Iodine. *Lancet* **2**: 41-46, 84-91, July 8 and 15, 1950.
10. SPIERS, F. W.: Materials for Depth Dose Measurement. *Brit. J. Radiol.* **16**: 90-97, March 1943.

Westminster Hospital  
St. John's Gardens, S.W. 1  
London, England

## SUMARIO

## El Uso de Radio-Yodo en el Estudio de los Trastornos Tiroideos

Describese aquí una técnica sencilla y que no requiere aparatos complicados para estudios diagnósticos del tiroides. Se hace un molde en yeso de la región tiroidea y de otras zonas que interesen, pintándose en el mismo varios puntos anatómicos de referencia y dividiendo la superficie con una regla en cuadrados de 13 cm. Despues de la administración del isótopo, se hacen numeraciones con la caja en posición, y se anotan las cifras a intervalos de 2 cm. Por las gráficas de las cifras obtenidas, cabe deducir las coordenadas de un punto que muestra cierta cifra dada. Luego se trazan en el molde curvas de isonumeraciones. Se ha demostrado que, con el plan descrito, el borde geométrico de la

zona de concentración del yodo coincide toscamente con la curva de isonumeración de 50 por ciento. En esta forma puede determinarse la distribución del radio-yodo debajo de la caja en relación con los puntos anatómicos de referencia.

Desde el punto de vista clínico, el método ofrece un medio rápido de investigar la absorción de yodo en una región dada. No es un método cuantitativo y, por ejemplo, no puede usarse en la investigación de la tirotoxicosis. Si proporciona orientación valiosa en el tratamiento futuro del carcinoma tiroideo, pues indica si es o no suficiente la absorción en la glándula o en los tumores secundarios en casos en que no hay signos de absorción.



## The Effect of Kilovoltage and Grid Ratio on Subject Contrast in Radiography<sup>1</sup>

H. E. SEEMANN, Ph.D., and H. R. SPLETTSTOSSE, B.S.

A GOOD RADIOPHOTOGRAPH is the net result of favorable conditions with respect to two basic physical factors: contrast and definition. Contrast is determined by the relative intensities in the x-ray image pattern which reaches the film and by the contrast characteristics of the latter, which determine how this pattern will be rendered as photographic densities. Definition is affected by screen unsharpness and graininess, penumbra due to geometric conditions, and unsharpness due to motion of the body part. No one can say that definition is more important than contrast or *vice versa* for, in a radiograph with insufficient contrast, brightnesses over the area are too nearly the same for satisfactory discrimination, while with poor definition, areas of one density merge into another so gradually that the diffuse image cannot be interpreted. We recognize that only a small part of the whole problem of image quality can be dealt with adequately at a time and that other parts also merit consideration. In this paper we are reporting on an experimental study of one aspect of contrast, namely, "subject contrast."

We define subject contrast as the ratio of x-ray intensities between the parts of the x-ray image under consideration. It may be measured in various ways: as by the brightness ratios in a fluoroscopic screen image or by the ratios of ionization chamber readings. Since the result is a *ratio*, the values for different methods will agree even if their x-ray spectral response is not the same, provided the quality of the x-ray beams being compared is the same. Although different intensities may be different in spectral quality because of difference in filtration, this is inappreciable if the subject contrast is low, as is the case

TABLE I: EFFECT OF SCATTERED RADIATION ON SUBJECT CONTRAST

Assumed Values of $I_s$	$\frac{I_p + I_s}{I_{pw} + I_s}$	Subject Contrast
0.00	$1.10 + 0.00$	1.10
	$1.00 + 0.00$	
0.50	$1.10 + 0.50$	1.067
	$1.00 + 0.50$	
1.00	$1.10 + 1.00$	1.05
	$1.00 + 1.00$	
2.00	$1.10 + 2.00$	1.033
	$1.00 + 2.00$	
3.00	$1.10 + 3.00$	1.025
	$1.00 + 3.00$	
5.00	$1.10 + 5.00$	1.017
	$1.00 + 5.00$	
10.00	$1.10 + 10.00$	1.009
	$1.00 + 10.00$	

in many of the areas in a radiograph which are of diagnostic importance.

Subject contrast may also be measured with x-ray film, if the latter is calibrated for the purpose. Referring all film densities to the sensitometric curve obtained from strips developed in the same manner as the experimental strips eliminates the contrast characteristics of the film. Thus, the time of development or the kind of film chosen does not affect the results so long as the calibration is obtained for the same processing conditions. It is to be emphasized that the objective of this experiment is to study the relations of kilovoltage and grid ratio and that film is used as a measuring medium rather than as a radiographic medium. If we did not refer to the intensity calibration of the film, its characteristics, e.g., contrast as a function of density, would introduce another variable and confuse the interpretation of changes caused by kilovoltage and scattered radiation. There is no fundamental objection to measuring subject contrast with an ionization chamber, but its

<sup>1</sup> Communication No. 1689 from the Kodak Research Laboratories. Presented at the Fortieth Annual Meeting of the Radiological Society of North America, Los Angeles, Calif., Dec. 5-10, 1954.

physical dimensions make it awkward for application to small areas. Furthermore, in our experiments, the intensities transmitted by a small, stepped wedge were all recorded on one film simultaneously in a single exposure, whereas, if an ion chamber were used, the same values would require as many exposures as there are steps.

Before considering the details of our work, it may be of interest to digress to the extent of illustrating the effect of scattered radiation on subject contrast. The numerical values chosen for Table I are assumed values which are reasonable in the light of knowledge based on our earlier measurements (1):

$I_p$  = Primary intensity through phantom, scatter excluded;

$I_{pw}$  = Primary intensity through phantom and wedge, scatter excluded;

$I_s$  = Scattered radiation intensity, assumed to be uniform over the image area.

Let  $I_p/I_{pw} = 1.10$ , i.e., the primary beam, without scatter, is assumed to be 10 per cent more intense through the area near the wedge than through a particular step of the wedge. Thus, under these conditions, the subject contrast is 1.10. With an intensity of scatter,  $I_s$ , over the entire area, this quantity must be added to both numerator and denominator of the fraction, so that, under scattering conditions, the subject contrast is given by

$$\frac{I_p + I_s}{I_{pw} + I_s}.$$

Thus, we see the very pronounced effect of scattered radiation for an x-ray beam in which one part is 10 per cent more intense than another *without* scattered radiation but is less than 2 per cent more intense if the scatter, for example, is five times more intense than the primary, image-forming radiation.

Although scattered radiation increases somewhat with kilovoltage, the principal effect of a kilovoltage change is the change in effective absorption coefficient of the

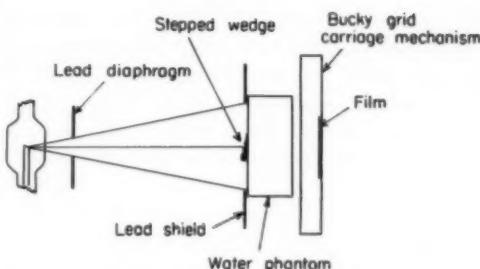


Fig. 1. Schematic diagram of experimental arrangement.

material penetrated. In general, the absorption coefficient decreases with increasing kilovoltage; hence the subject contrast also decreases.

If the Potter-Bucky diaphragm is introduced, the increase in subject contrast due to removal of scattered x-rays may be more or less offset by increasing the kilovoltage. Restriction of the irradiated area by coning yields higher subject contrast because of the lesser amount of material in the beam to contribute scattered radiation. Our results show, in some detail, the relation of kilovoltage, grid ratio, and phantom thickness to subject contrast.

#### EXPERIMENTS AND RESULTS

The general purpose of our experiments was to measure subject contrast under a variety of conditions which are within the possible range of medical radiographic procedure. In its broadest aspects, our work resembles that of Nemet, Cox, and Hills (2) and of Gajewski (3), but it was planned and carried out quite independently. Water phantoms were radiographed at several kilovoltages, using grids of several ratios at each kilovoltage. On the side of the phantom toward the x-ray tube were placed two stepped wedges, one of Lucite and one of artificial bone (Fig. 1). Different wedge thicknesses were chosen for the different phantom thicknesses so as to obtain a reasonable range of subject contrasts for a given phantom. The steps of the wedges were about 1 cm. square. The bone wedge was a solidified mixture of equal parts by weight

of powdered clean beef bone and a plastic composed of 60 per cent No. 121 Vibrin and 40 per cent No. 108 Vibrin.<sup>2</sup> This mixture was a homogeneous mass, a feature required to provide a uniform density on the recording film for reading on a densitometer.

In Figure 2 are shown some of the plots of data obtained in this manner. Note the extremely low contrast with no grid (A); a value of only 1.1 is attained at 60 kvp for step No. 6, but the same contrast occurs at only 2 1/2 steps at 175 kvep with the use of a 5:1 grid (B). Or consider the contrast of step No. 3. It is 1.25 at 60 kvp with the 5:1 grid, and the same at 125 kvep with the 8:1 grid, but if a 16:1 grid were used, it would apparently be necessary to exceed 175 kvep to obtain the same subject contrast.

The graphs of Figure 2 are illustrative of the plots of the original experimental data. Data were also obtained for the many conditions used in this investigation which involved tests of water phantoms of 5.7-cm., 11.4-cm., and 17.1-cm. thickness, stepped wedges of Lucite and of artificial bone, peak kilovoltages of 40, 50, 60, 70, 80, 90, 100, 125, 150, and 175.<sup>3</sup> The grids used had the following ratios: 5:1, 6 1/2:1, 3 1/2 × 3 1/2:1 (90°-45° criss-cross), 8:1, and 16:1.

In Figure 3 are shown graphs of subject contrast *versus* kilovolts for all of the conditions that were used. These graphs were derived from original plots similar to and including those in Figure 2. Because the original curves were drawn so as to give a graphical average, no data points are shown in Figure 3.

The curves in Figure 3 showing subject contrast for the 7:1 grid and the 8:1 grid cross when the thick phantom is used. The 7:1 grid, which is composed of two 3 1/2:1 grids at 45°, was found in our earlier work (1) to be more efficient than

the 8:1 grid at low kilovoltages but less efficient at high kilovoltages. This is in general agreement with the present findings. Apparently, the geometry of the crossed 3 1/2:1 grids is a little better than the 8:1, but the number of lead strips is insufficient in the former to provide adequate absorption of the more penetrating scatter at wide angles.

A radiograph of a small, stepped wedge with the water phantom near the x-ray tube, the beam diaphragmed, and the wedge near the film, should show the maximum subject contrast at a given kilovoltage because of the absence of appreciable scattered radiation. The "no scatter" curves in Figure 3 were obtained in this manner. However, if the phantom is placed near the film, a more or less uniform exposure due to scattered radiation will also be recorded. There is no reason to suppose that the former arrangement with a subsequent "flash" exposure equal to the amount of scatter from the phantom should be any different than if the two occurred simultaneously. We have, in fact, tried such an experiment, radiographing a wedge without scatter and making subsequent flash exposures of predetermined amounts on the same film with the wedge removed. When the data were plotted, *viz.*, subject contrast *versus* step of the wedge, a family of curves was obtained similar to the curves in Figure 2, but instead of each curve representing the use of a certain grid, each represented a certain proportion of "scattered radiation." Since the amount of scattered radiation is known for a given set of conditions and a specified grid (1), a comparison was made between this simulated scattered radiation and the actual scattered radiation. There was agreement within the limits of our experimental error. This is not a new concept, nor are the results unexpected. The value of the test lies in its illustration of the fact that scattered radiation is just an additional exposure which, instead of forming an image, changes the relationships within the image by a uniform exposure.

<sup>2</sup> We acknowledge the services of E. Alden and F. Stahly, of these Laboratories, in preparing this mixture.

<sup>3</sup> A constant potential machine was operated at 140 and 164 kvp to simulate radiographic conditions of 150 and 175 kvp, respectively.

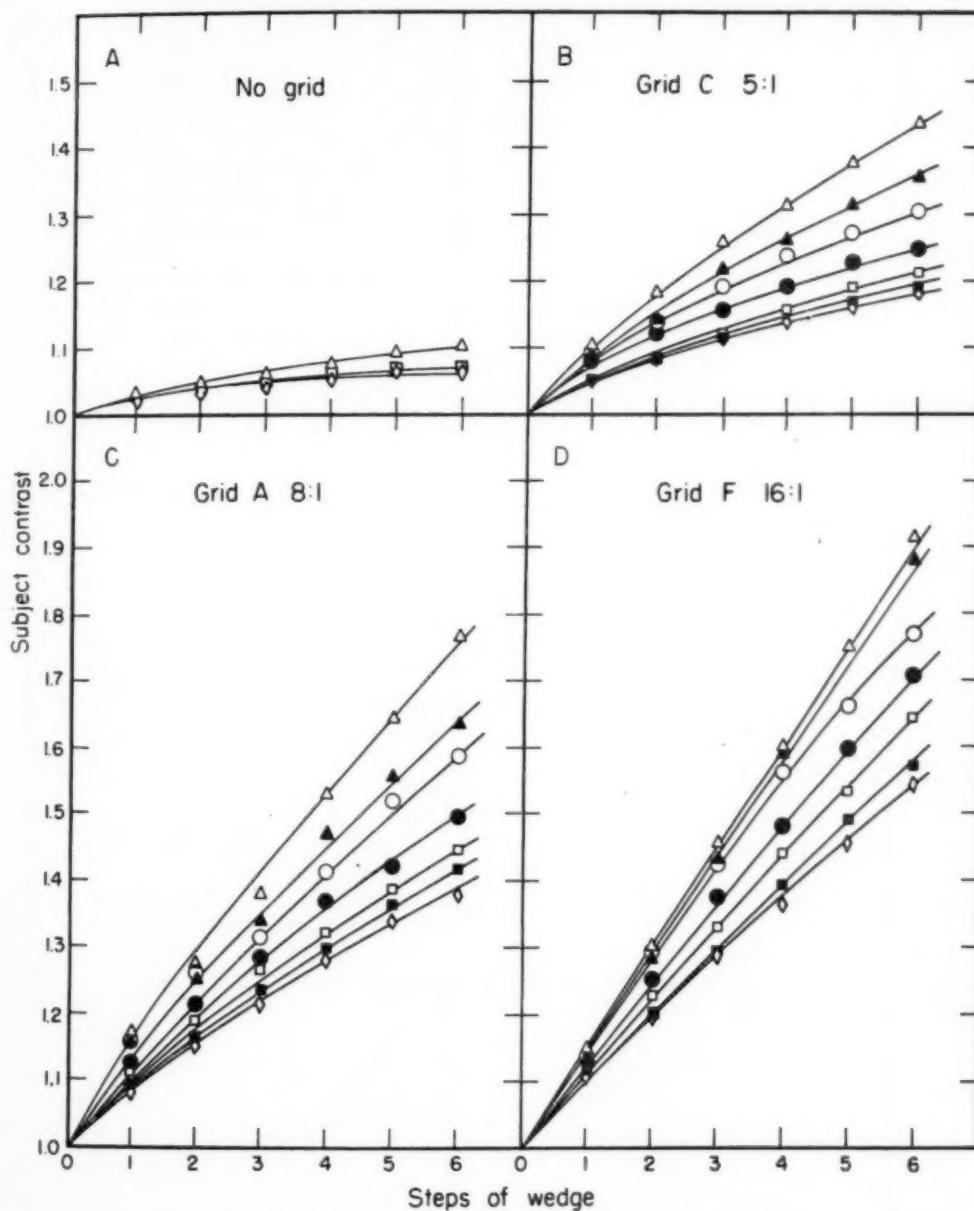


Fig. 2. Examples of plots of the original data. Beginning with the lowest curve and reading up, the kilovoltages used were: 164 kVp ( $\diamond$ ); 140 kVp ( $\blacksquare$ ); 125 kVp ( $\square$ ); 100 kVp ( $\bullet$ ); 80 kVp ( $\circ$ ); 70 kVp ( $\blacktriangle$ ); and 60 kVp ( $\Delta$ ). Only 164 kVp, 125 kVp, and 60 kVp are included in the "no grid" plot, to avoid confusion.

Reducing scattered radiation with a grid naturally requires that additional exposure with the primary radiation be made to obtain a satisfactory radiographic ex-

posure. This may be accomplished by raising the kilovoltage; yet so rapid is the increase in penetration with increasing kilovoltage, and so effective is the removal

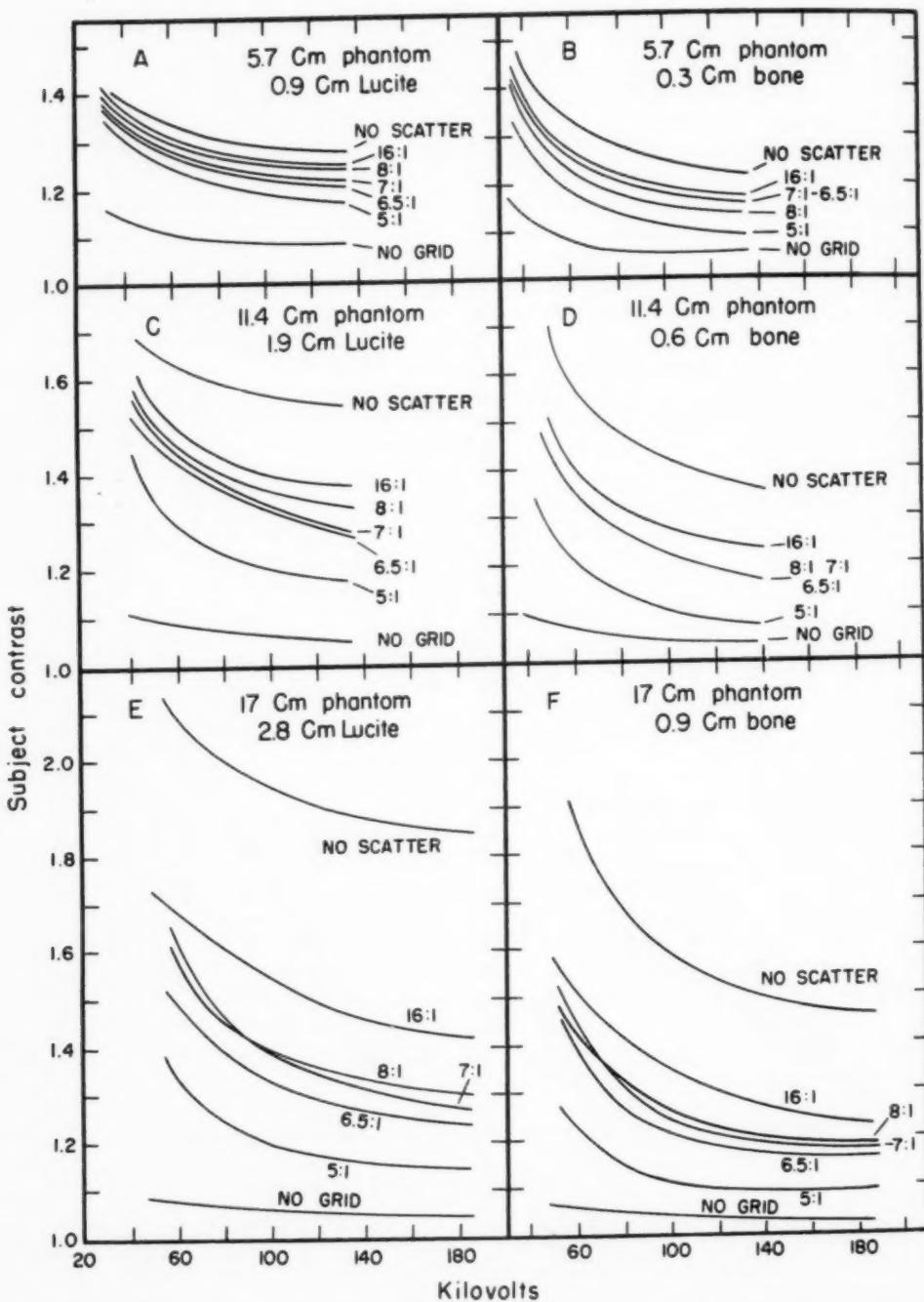


Fig. 3. Graphs derived from curves like those shown in Fig. 2. The thicknesses of Lucite and bone given are those for which the subject contrast was determined.

of scatter in increasing subject contrast, that one may actually attain higher contrast at high kilovoltage *with* a grid than at low kilovoltage *without* a grid, as we have seen in Figure 3. For the same heat load on the focal spot, more useful radiation is available at the film at high kilovoltage, and the radiation dosage received by the patient may be considerably lessened (2-7).

There is, however, a limit to the advantages gained by grids and the use of higher kilovoltages. Wilsey has shown that the exposure of normal adult chests of medium size is formed by about 45 per cent primary radiation and 55 per cent scattered radiation (8). This condition is approximated by the 5.7-cm. phantom (9), for which the subject contrast curves are shown in Figure 3, A and B. These curves show that, for such relatively small amounts of scattered radiation, an 8:1 grid is almost as useful as a 16:1 grid. Also, it has been shown that the 16:1 grid absorbs appreciably more primary radiation than the 8:1 grid (1). Therefore, the small gain in subject contrast in changing from an 8:1 grid to a 16:1 grid technic might not be worth while because of the increased exposure required to make up for the higher absorption. The 16:1 grid should be employed only when it offers a significant advantage by increasing the subject contrast.

Another approach to the matter of choice between the 8:1 and the 16:1 grid is as follows: For simplicity, it is assumed that an 8:1 grid is 90 per cent efficient and that a 16:1 grid is 95 per cent efficient (1). Let a chest exposure be composed of one-half primary radiation and one-half scattered radiation. With the 8:1 grid, 90 per cent of 50 per cent of the exposure will be removed, leaving only 5 per cent, which is 9.1 per cent of the total exposure. A similar calculation shows that the 16:1 grid leaves scatter remaining to the extent of 4.8 per cent of the total exposure. Although the one value is almost twice the other, both are only a small part of the total exposure. But suppose a heavy

TABLE II: EFFECT OF KILOVOLTAGE ON RELATIVE SUBJECT CONTRAST OF BONE AND LUCITE

Kilovolts	Relative Subject Contrast Bone/Lucite
60	1.0
80	0.95
100	0.92
125	0.91
175	0.90

body part is radiographed, with the non-grid exposure consisting of ten parts scatter and one part primary radiation. As the 8:1 grid is assumed to be 90 per cent efficient, it removes nine parts of the scatter, so that the exposure then consists of half scatter and half primary! If the 16:1 grid is used, the exposure will consist of one-third scatter and two-thirds primary, a very significant difference. Thus, we conclude that it is scarcely worth while to push scatter removal to the limit if the initial amount is not very large, as in the case of chests, but it is worth while if the amount is several times greater than the primary radiation.

#### BONE VERSUS LUCITE

It has been mentioned in the literature (2, 5) that with increasing kilovoltage there is a greater loss of detail in radiographic images of bone structure than in tissue structure. We have found from the "no scatter" curves in Figure 3 that the subject contrast does decrease more rapidly for bone than for Lucite. This is to be expected from the known change with energy of the absorption coefficients of calcium and water (10). In Table II are listed relative subject contrasts for bone and Lucite when exposed through the 17-cm. water phantom used as a filter. Values are normalized to unity for 60 kv. The value of 1.0 means that at 60 kv some chosen thickness of Lucite has the same absorption as a certain thickness of the artificial bone.

These observed changes in subject contrast may seem small, but it must be kept in mind that we are dealing with continuous spectrum x-rays, for which the "absorption coefficient" does not change

with kilovoltage as rapidly as for monoenergetic radiation of the same nominal kilovoltage. Furthermore, the bone substance of the bone wedge is "diluted" with the plastic binder.

In comparing actual medical radiographs, it has seemed to us that the loss of detail with increasing kilovoltage was greater than could be entirely accounted for by the diminishing subject contrast. We recalled the work of Widemann (11), who claimed that various grades of intensifying screens were similar in their definition properties above 120 kv and when radiographing more than about 12 mm. of steel. When we read Widemann's paper, we were somewhat skeptical and made similar tests.<sup>4</sup> Our results agreed substantially with his. This tendency of all grades of intensifying screens to give similar definition in hard-radiation techniques presumably means that the fine-grain types become poorer with increasing kilovoltage. Since bone generally has a much finer structure as seen in the radiograph than does tissue, the loss of definition associated with the change in screen characteristics must be more apparent when studying bone detail than when studying tissue detail. We suspect that, if this effect is significant in medical radiography, it is *partially* responsible for the opinion that the greater loss of detail in bone compared with tissue is attributable simply to the relative change in subject contrast with kilovoltage. It is our opinion that we are dealing with a contrast effect and a screen effect, both of which happen to operate in the same direction with respect to visibility of detail. Further study will be required to test this hypothesis.

In a recent paper, Meiler (12) reports, among other findings, that the unsharpness of an intensifying-screen image depends upon the kilovoltage, being greater at the higher kilovoltages. The effect is small but, since he used the unfiltered con-

tinuous spectrum, a wave-length effect would be less pronounced than if a more homogeneous spectrum were used. Meiler's results lend further support to our opinion that the visibility of fine detail is adversely affected by the effect of high kilovoltage on the definition of intensifying screens.

#### SUMMARY

A quantity called "subject contrast" is defined. It is the ratio of x-ray intensities between the parts of the x-ray image under consideration and is essentially independent of the method of measurement.

The effect of scattered radiation on the value of the subject contrast is illustrated. In a series of experiments with water phantoms, subject contrast was found to vary with kilovoltage and grid ratio, decreasing with increasing kilovoltage and increasing with grid ratio. It is shown from the curves obtained that many conditions exist in which scatter removal more than offsets the decrease of contrast with increased kilovoltage.

With increasing kilovoltage, subject contrast of bone substance decreases more rapidly than does subject contrast of tissue-like substance.

Further experimentation will be required to determine whether image definition (as distinct from contrast) is adversely affected by the use of the higher kilovoltages.

#### REFERENCES

1. SEEMANN, H. E., AND SPLETTSTOSSE, H. R.: Some Physical Characteristics of Potter-Bucky Diaphragms. *Radiology* **62**: 575-583, April 1954.
2. NEMET, A., COX, W. F., AND HILLS, T. H.: The Contrast Problem in High Kilovoltage Medical Radiography. *Brit. J. Radiol.* **26**: 185-192, April 1953.
3. GAJEWSKI, H.: Physikalische und aufnahmetechnische Gesichtspunkte bei Röntgenaufnahmen mit hohen Spannungen. *Fortschr. a. d. Geb. d. Röntgenstrahlen* **80**: 643-649, May 1954.
4. TROUT, E. D., GRAVES, D. E., AND SLAUSON, D. B.: High-Kilovoltage Radiography. *Radiology* **52**: 669-683, May 1949.
5. WACHSMANN, F., BREUER, K., AND BUCHHEIM, E.: Grundlagen und Ergebnisse der Hartstrahltechnik. *Fortschr. a. d. Geb. d. Röntgenstrahlen* **76**: 147-157, February 1952.
6. LINDBLOM, K.: On Roentgenography at 200 kv. *Acta radiol.* **36**: 162-164, August 1951.

<sup>4</sup> Tests made several years ago in these Laboratories by R. G. Tobey.

7. FOSSATI, F.: High-Voltage Radiography. *Ferraria* **6**: 2-3, August 1952.
8. WILSEY, R. B.: Scattered Radiation in Roentgenography of the Chest. Preliminary Report. *Radiology* **23**: 198-201, August 1934.
9. WILSEY, R. B.: The Intensity of Scattered X-rays in Radiography. *Am. J. Roentgenol.* **8**: 328-338, June 1921.
10. WHITE, GLADYS R.: X-Ray Attenuation Coefficients from 10 Kev to 100 Mev. National Bureau of Standards Report 1003, May 13, 1952.
11. WIDEMANN, M.: Über Verstärker als Hilfsmittel der Röntgenprüfung metallischer Körper. *Fortschr. a. d. Geb. d. Röntgenstrahlen* **55**: 391-398, April 1937.
12. MEILER, J.: Die Unschärfe von Verstärkerfolien. *Fortschr. a. d. Geb. d. Röntgenstrahlen* **80**: 749-754, June 1954.

Research Laboratories  
Eastman Kodak Co.  
Rochester, N. Y.

#### SUMARIO

#### El Efecto del Kilovoltaje y de la Proporción de la Rejilla sobre el Contraste del Sujeto en la Radiografía

Se define la expresión "contraste del sujeto" como la proporción de intensidades de rayos entre las partes de una imagen dada. Al determinar experimentalmente el contraste del sujeto por una impresión en película radiográfica, calibrada para dicho fin, se interpretan las densidades como intensidades de rayos X por referencia a la típica curva sensitométrica de la película. El procedimiento consistió en hacer exposiciones a través de fantasma de agua sobre los cuales se colocaron cuñitas graduadas de Lucite y hueso artificial. Se hicieron exposiciones a través de distintas cantidades de agua a varios kilovoltajes y proporciones de la rejilla de Bucky. Se valuaron los contrastes del sujeto en esas varias situaciones. La cantidad de radiación esparsa, determinada en gran parte por la proporción de la rejilla, y la absorción de los rayos X, determinada por el kilovoltaje aplicado al tubo de rayos X, ejercieron notable efecto sobre el contraste del sujeto. Por ejem-

plo, observóse que el contraste del sujeto obtenido a un kilovoltaje bajo y con una proporción baja de rejilla podía obtenerse con un kilovoltaje mucho más alto si se usaba una rejilla de proporción alta. Observóse que el contraste del sujeto para el hueso disminuía más rápidamente que para otro tejido al aumentar el kilovoltaje, efecto este que es de esperar por el conocido cambio de los coeficientes de absorción del calcio y del agua.

Al comparar radiografías médicas reales, pareció que la pérdida de detalle ocurrida al acrecentar el kilovoltaje es mayor que la que puede atribuirse totalmente a la disminución del contraste del sujeto. Opinan los AA. que las pantallas intensificadoras tal vez no faciliten tan buena definición a un kilovoltaje alto como a uno bajo y, por lo tanto, que los delicados detalles del hueso sufren relativamente más que los detalles de tejidos más groseros. Se requieren estudios ulteriores para comprobar esta hipótesis.

#### DISCUSSION

**George C. Henny, M.D.** (Philadelphia, Penna.): This paper is an excellent analysis of problems about which radiologists are often heard to argue. Arguments on the subject frequently are not resolved, because they are usually based on conditions of monoenergetic radiation which do not exist. Fortunately, Dr. Seemann and Mr. Splettstosser are using radiation as it comes from the radiographic tube. Apprehension may be aroused because they are employing a film method to measure relative x-ray intensities and contrast. The vagaries of using

photographic emulsion for quantitative measurements are well known and are difficult to overcome. The senior author in particular, and the laboratories in which he works, are especially well equipped to handle such problems. So we can feel confident that the data given to us are trustworthy.

It must be clearly kept in mind, as the authors emphasize, that they are discussing comparisons or ratios of x-ray intensities, and not film densities. The conversion of the x-ray or subject contrast to film density contrast is another step which has been

discussed elsewhere. It should also be remembered that, as they define subject contrast, a contrast of 1.00 indicates that the x-ray intensity through the phantom and wedge is equal to the intensity through the phantom alone (scatter excluded). Thus the wedge would not be discernible. It is natural to think of this as zero contrast, since both wedge and its surroundings would be of the same density on the radiograph. Mathematically it is more convenient to call this contrast equal to 1.00.

From the values of scattered radiation and subject contrast which are given in Table I and which are practical values found in practice, it is interesting to note how small the subject contrast often is when compared to the amount of scattered radiation. The importance of a high-ratio grid in thick-part radiography is well brought out. The authors were careful not to base their findings on a bone phantom

alone. A Lucite phantom (as well as water) was used to simulate soft tissue.

The reason for the fact that at high kilovoltages the ribs on a chest radiograph are of such low contrast that lung shadows may be seen through them is well demonstrated by the no-scatter curves of Figure 3. The steepness of the subject contrast of the bone occurs because the absorption coefficient of calcium and phosphorus changes so rapidly as kilovoltage goes up, whereas the change for soft tissue is much less. The unfavorable loss of detail in bone at high kilovoltage is largely an intensifying screen phenomenon. Thus, if the radiologist is interested in bone lesions, he may use low kilovoltage and fine-grain intensifying screens. If he wants a wide latitude radiograph which shows soft-tissue details through the bones, he may go to high kilovoltage with a high ratio grid.



## Intragastric Gallstone

J. K. AFFLERBAUGH, M.D., and HAROLD A. COLE, M.D.

THE RADIOLOGIST is well aware of cholecystoenteric fistulae with discharge of gallbladder calculi into the gastrointestinal tract and the acute obstructions that may thus develop. Gallstones have been seen within the duodenum, jejunum, ileum, and colon. McLaughlin and Raines (1) mention intragastric calculi in an excellent review of obstruction of the alimentary tract from gallstones. Their single case of an intragastric calculus was very similar to that reported here, but they presented no radiographic demonstration. We have seen no other reference to gallstones within the stomach.

### CASE REPORT

An 80-year-old white male first consulted a general practitioner in October 1950, because of right upper quadrant pain radiating to the heart. A cholecystogram at that time revealed what was interpreted as a poorly functioning gallbladder with evidence of a small solitary calculus with a calcific core and a radiolucent periphery (Fig. 1). Blood studies showed an unexplained anemia, with a hemoglobin of 40 per cent, which increased to 58 per cent on a blood-building regime.

In January 1951, the patient was seen in consultation by one of the present authors (J.K.A.). He complained of weakness of four to six months duration and a gradual weight loss of 15 pounds in that time. For many years he had suffered from indigestion, especially following fatty foods, with occasional right upper quadrant pain. Bowel movements were sluggish, but there had been no clayey or tarry stools. For the past ten years there had been mild attacks of decompensation. The patient had never been jaundiced.

Physical examination revealed some cardiac enlargement of left ventricular type. A slightly tender mass was palpable in the right upper quadrant of the abdomen. It was questionably nodular and compatible with a mass in either the gallbladder or the liver. The blood count showed a hemoglobin of 8.4 gm. (53 per cent), a red cell count of 2,850,000, white cells 2,550, with lymphocytes 40 per cent, neutrophils 40 per cent, eosinophils 4 per cent, basophils 1 per cent. The clinical impression was anemia, probably associated with a malignant tumor of the gallbladder.

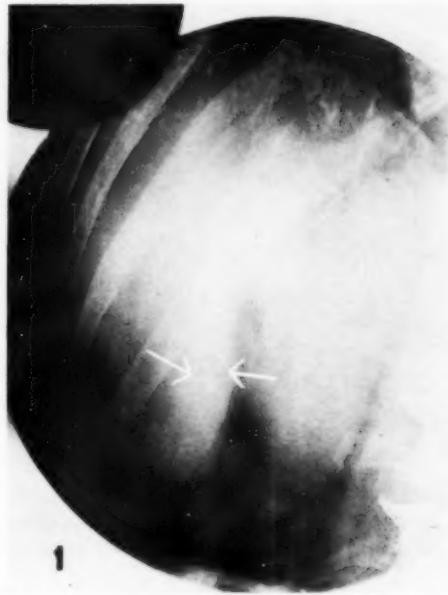


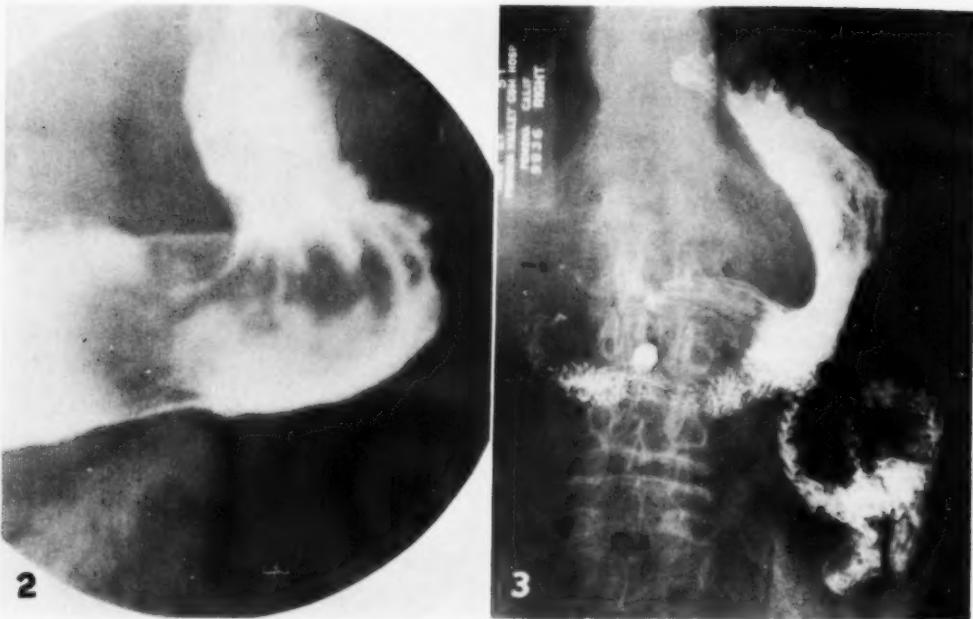
Fig. 1. Cholecystogram,<sup>1</sup> October 1950, interpreted as indicating poor gallbladder function with a small solitary calculus. Note small calcification with radiolucent periphery in the region of the body.

At operation (Feb. 18, 1951), the gallbladder was found to be slightly enlarged, grayish white, firm, but slightly friable. It was adherent to the transverse colon, duodenum, and stomach. It was thought that the patient probably had a carcinoma of the biliary tract but, since he was not tolerating surgery well, it was felt inadvisable to attempt any further exploration of the cystic and common duct. A wedge-section was taken from the fundus of the gallbladder and the abdomen was closed. The pathologic report was "severe chronic inflammation of the gallbladder area."

The patient was discharged on March 4 and until November of that year was followed symptomatically and also given a series of blood transfusions. On Nov. 15, 1951, he was readmitted following a gastric hemorrhage. An upper gastrointestinal series was completed on Nov. 21. This showed, in contrast to the negative examination of the preceding January, a large intraluminal polypoid mass (Figs. 2 and 3).

Fluoroscopically the mass appeared to be in the body of the stomach, but with the patient prone,

<sup>1</sup> From the Pomona Valley Community Hospital, Pomona, Calif. Accepted for publication in March 1954.



Figs. 2 and 3. Upper gastrointestinal films, November 1951. Fig. 2 is a spot view of a "polypoid" mass in the body of the stomach with the patient upright, subsequently proved to be a large intragastric calculus. Examination completed following gastric hemorrhage. An upper gastrointestinal series ten months previously had been negative. In Fig. 3, with the patient prone, the mass is seen to have moved higher along the greater curvature of the stomach. The antral "defect" merely represents pressure from the spine. The arrow points to a small channel near the apex of the duodenal bulb, the probable remnant of a cholecystoduodenal fistula.



Figs. 4 and 5. Roentgenogram and photograph of the huge gallstone removed from the stomach. Note the central nidus in the calculus as shown on the roentgenogram and compare with Fig. 1.

it seemed to move higher and nearer the fundus, as shown in Figure 3. It was concluded that it was probably a large polypoid carcinoma on a pedicle. A bezoar was suggested as a possibility, but the true nature of the mass was not realized.

The patient was again operated on, Nov. 26, 1951. Palpation at this time revealed a mobile mass, about  $8 \times 3$  cm., within the stomach. A longitudinal incision in the anterior gastric wall disclosed a banana-shaped gallstone which was removed without difficulty (Figs. 4 and 5). Inspection of the gastric mucosa revealed no evidence of polypoid tumor or ulcer and no bleeding points. The gastric mucosa presented the cobblestone appearance of a chronic atrophic gastritis. The pylorus was dilated and permitted easy entrance of two fingers. In the lateral posterior portion of the duodenum, a puckered indurated area that may have represented an ulceration was found. The serosal surface of the duodenum in this region was thickened and pearly white with scar tissue. It was the surgeon's opinion that the stone had dilated the pylorus and one end had lodged against the duodenum in this region, and this was assumed to be the probable source of hemorrhage. The stone was easily dislodged and returned to the stomach. The gallbladder was thickened and contracted, with pearly white, dense fibrous connective tissue, and was intimately adherent to the middle portion of the duodenum. These adhesions were not disturbed. No surgery was attempted other than the removal of the gallstone.

## DISCUSSION

It is obvious, when one compares Figures 1 and 4, that what was originally interpreted as a poorly functioning gallbladder with a small calculus actually represented a huge calculus within the gallbladder itself. The large gallstone shows a small central nidus that is faintly visualized on the initial cholecystographic study.

It is fairly certain that between October 1950, at the time of the first cholecystogram, and November 1951, when the final gastrointestinal series was completed, this calculus had passed through a cholecystoduodenal fistula and thence, through the pylorus, into the stomach. In Figure 3 a small channel is seen in the upper part of the duodenal loop, which undoubtedly represents the remnant of the fistula. At surgery the fistulous tract was presumably already healed.

The surgeon found the calculus partly impacted in a patulous pylorus but, judging from the previous gastrointestinal study, it was freely movable within the stomach, so that it was probably causing some intermittent pyloric obstruction, as in the case of McLaughlin and Raines. In the case of Riesser and Vicas (2) a similar large calculus was impacted in the duodenal cap. Undoubtedly that case represents a stage in the retrograde expulsion of such a calculus through the pylorus into the stomach. Mention is made of cholecystogastric fistulae, but certainly none was present in our case.

The patient was recalled for a cholecystogram and upper gastrointestinal series in March 1953, and a faint contracted gallbladder shadow was obtained. The upper gastrointestinal series was negative except for a slight periduodenal defect just beyond the apex of the bulb, undoubtedly representing the dense adhesions seen at surgery. The patient was eighty-two years old at that time. To date he remains relatively asymptomatic and in satisfactory condition.

## SUMMARY

A case is presented in which a large gallstone was demonstrated radiologically in the stomach and was subsequently removed. There is sufficient proof to establish that this huge calculus had passed through a cholecystoduodenal fistula and thence through the pylorus into the stomach. A previous cholecystographic study had revealed the calculus within the gallbladder, before its passage into the duodenum and stomach. Though mention has been made of intragastric gallstones, no other report of their radiographic demonstration could be found.

1798 N. Garey Ave.  
Pomona, Calif.

## REFERENCES

1. McLAUGHLIN, C. W., JR., AND RAINES, M.: Obstruction of the Alimentary Tract from Gallstones. *Am. J. Surg.* **81**: 424-430, April 1951.
2. RIESER, J. F., AND VICAS, B.: Gallstone Impacted in the Duodenal Cap. *Radiology* **58**: 401-404, March 1952.

## SUMARIO

## Cálculo Biliar Intragastrico

Presentase un caso en el que se descubrió radiológicamente un cálculo biliar grande en el estómago, extrayéndose después. Hay prueba suficiente de que este enorme cálculo había atravesado una fistula colecistoduodenal, pasando de allí a través del píloro al estómago. Un

estudio colecistográfico anterior había mostrado este cálculo en la vesícula biliar, antes de pasar al duodeno y estómago. Aunque ha habido mención de cálculos biliares intragástricos, no ha podido descubrirse ninguna otra reseña de su observación radiográfica.

## Volvulus of the Blind Ileal Loop Following Ileosigmoidostomy

### A Case with Perforation<sup>1</sup>

JOAN ELIASOPH, M.D., RICHARD H. MARSHAK, M.D., and BERNARD S. WOLF, M.D.

**V**OLOVULUS OF THE ileal stump in a side-to-side ileocolic anastomosis is a rare complication of intestinal surgery. Such a case, with several unusual roentgenologic findings, is presented.

R. G., a woman aged 60, was admitted to the hospital because of abdominal cramps and weight loss over a period of six months, vomiting and diarrhea for two weeks, and constipation for two days preceding entry. She proved to have an incomplete intestinal obstruction, and exploratory laparotomy was undertaken. An infiltrating colloid carcinoma of the cecum with lymph node metastases was found, and an isoperistaltic side-to-side ileosigmoidostomy with exclusion was performed. The blind ileal stump extended 3 inches beyond the anastomosis. A second-stage ileocolic resection was done approximately six weeks later, including the terminal ileum, ascending colon, and hepatic flexure.

The patient was discharged to the follow-up clinic, asymptomatic, approximately three months after her original entry. She remained well for over four years, at the end of which time she began to experience postprandial distress, relieved by rushes of borborygmi. Physical examination at that time was negative. Barium enema examination (Figs. 1 and 2) showed a free flow of barium from the rectum to the sigmoid. At this point the barium column divided into three parts. One passed through the stoma, visualizing the blind loop of ileum, which was slightly dilated and approximately 8 inches in length, another into normal proximal small bowel, and the third into the remaining colon, which showed no abnormalities. Sigmoidoscopy three months later was negative to 7 inches. The anastomosis was not visualized.

Five months later the patient was seen in the emergency room complaining of four days of abdominal distention, belching, left-sided abdominal pain, and obstipation.

Roentgen examination of the abdomen (Fig. 3) now revealed considerable free air under the diaphragm. There was a tremendously dilated loop of bowel in the mid-line, apparently arising from the pelvis and extending to the level of the first lumbar vertebra. It was difficult to determine the exact nature of the dilated loop. It did not have the usual roentgen features of a volvulus of the sigmoid. However, the huge dilatation suggested a closed-



Fig. 1. Barium enema study revealing a large blind loop of ileum arising from the sigmoid at the site of ileosigmoidostomy and extending to the right side of the abdomen. The ileal stump measures approximately 8 inches in length. The ascending and proximal transverse colon have been resected. There is no abnormality in the remaining large intestine.

loop obstruction, the nature of which was undetermined.

At operation, a greatly distended loop of bowel presented in the wound and was identified as the blind ileal stump. Its tip was adherent to the anterior abdominal wall. The stump measured 6 inches in length and 5 inches in diameter and had been twisted twice at its base at the ileosigmoidostomy. The wall was extremely thin and there appeared to be a minute perforation at the tip. The mesentery of the redundant loop was ligated and divided, and the stump amputated and closed in the conventional fashion. The pathology report was hypertrophic blind loop of small bowel showing acute and chronic fibrinous serosal inflammation. The patient made an uneventful recovery and was discharged on the ninth postoperative day.

### DISCUSSION

Surgical complications of intestinal anastomoses apart from obstruction and per-

<sup>1</sup> From the Department of Radiology, The Mount Sinai Hospital, New York, N. Y. Accepted for publication in March 1954.

foration at the anastomosis are extremely uncommon. The case described illustrates one of these unusual sequela, namely, hypertrophy and torsion of the ileal stump in a side-to-side anastomosis. In the course of five years, the closed-over end of ileum enlarged to sufficient length that a relatively small degree of torsion was capable of producing infarction of



Fig. 2. Roentgenogram following evacuation. The blind ileal loop retains a large part of the injected barium. The ileosigmoidostomy and small bowel immediately proximal to the anastomosis are well visualized and show no abnormalities.

the blind loop, with the anastomosis itself as the fixed point of rotation. Because this involved segment was not in continuity with the fecal stream, the process of degeneration of the bowel wall was relatively far advanced before obstructive signs became prominent and perforation occurred. In the more common forms of volvulus, functional depression of the involved bowel produces early physiological obstruction and the nature of the process is more rapidly recognized clinically. Consequently, definitive surgical therapy is



Fig. 3. Roentgenogram of the abdomen obtained about eight months following the barium enema examination (Figs. 1 and 2). A large amount of gas is present in the peritoneal cavity. A markedly distended loop of bowel without plical or haustral pattern arises from the pelvis and extends in the mid-line to the upper abdomen. The large intestine is outlined by gas and is moderately dilated. The small intestine shows no evidence of obstruction. (Retouched.)

ordinarily instituted prior to advanced degeneration of the bowel wall with subsequent perforation such as was observed in this case.

This patient presented a difficult problem in roentgen diagnosis. It was not clear whether the diseased bowel loop was large or small intestine. Neither valvulae conniventes nor haustral markings could be identified. The characteristic features of sigmoid volvulus were not present, namely, a large dilated bowel loop arising from the left lower quadrant and crossing the midline toward the right upper quadrant, a beak-like deformity at the lower extremity of the dilated loop, fluid levels, and a lesser degree of dilatation in the descending than in the sigmoid colon. A small-bowel volvulus was not suspected because of absence

of small-bowel dilatation. The unusually long blind loop of ileum was not suspected as the site of volvulus, though a review of the previous barium enema examination

should have suggested that the symptoms were due to this abnormality.

622 West 168 St.,  
New York 32, N. Y.

#### SUMARIO

#### Vólvulo del Asa Ciega del Ileón Consecutivo a Ileosigmoidostomía

Preséntase un caso en el que una ileosigmoidostomía laterolateral fué complicada por vólvulo del asa ciega del ileón. En el transcurso de cinco años, el extremo cerrado del ileón se dilató a un largo suficiente para que una torsión relativamente pequeña produjera infarto del asa ciega, con la anastomosis misma como punto fijo de rotación. Por no hallarse el segmento afectado en el paso de la corriente fecal, el proceso de degeneración intestinal

estaba relativamente muy avanzado antes de que tomaran auge los síntomas oclusivos y de que ocurriera la perforación.

Roentgenológicamente, se observó el asa dilatada en la línea media, pero no pudo determinarse su naturaleza exacta. Los hallazgos no eran típicos de vólvulo de la sínfisis ilíaca y no se sospechó vólvulo del intestino delgado por no haber dilatación de éste. La operación puso de manifiesto la verdadera situación.



## WORK IN PROGRESS

### Some Physical Characteristics of a 45-Mev Linear Electron Accelerator for Therapeutic Applications<sup>1</sup>

ERICH M. UHLMANN, M.D., F.A.C.R., and CHARLES L. HSIEH, Ph.D.

A 45-mev electron linear accelerator of the traveling wave type has been installed in this hospital for the production of high-energy external electron beams intended for therapeutic purposes. The first electron beam was obtained from the accelerator on March 6, 1954. However, physical measurements and proper evaluation of the performance of the machine could be carried out only after the magnet system had been designed, manufactured, and installed; this system consists of two electromagnets, one for analyzing and the other for focusing, and is used for controlling the energy, the direction, and the dimensions of the electron beam.

The experimental results of certain measurements are summarized here. The design of the magnet system, the target-end equipment, and the methods that were used in these measurements will be described in a later contribution.

The output energy of the accelerator can be continuously varied from a minimum of 6 mev to a maximum of 36 mev at the present time. The reasons that the actually obtained maximum energy is short of the originally designed and stipulated 45 mev lie mainly in the present klystron which applies the power for the acceleration and does not produce the expected 18 megawatt peak power. With a different klystron tube and better adjustment, an output energy closer to the stipulated figure is expected.

The energy spectrum, measured with 1 per cent energy resolution at the target, was found to be of 15 per cent width between half-intensity points and with little dependence on the peak energy at which the measurements were made. The average target current<sup>2</sup> obtained without appreciable beam loading

<sup>1</sup> From the Tumor Clinic of Michael Reese Hospital, Chicago, Ill.

<sup>2</sup> i.e., practically mono-energetic electron flux that is delivered to objects at target after the electrons from the accelerator have been analyzed by the magnet system.

is  $10^{-2}$  micro-ampere for a 100-sq. cm. field. From the energy spectrum and the collimator dimension, the total output beam current<sup>3</sup> of the accelerator was calculated to be about 1 micro-ampere. The target current can be varied by a factor of  $10^4$ , the lower limit being set by the field emission and the upper limit dependent on the beam loading.

The electron beam at the target has a rectangular cross-section, the dimensions of both sides being adjustable from 1 to 12 cm. The current distribution over the target area was found to be uniform, with a steep drop at the geometrical boundaries. The electron beam at the target has a controllable energy resolution of 2 per cent maximum and is slightly divergent, with an approximate  $2^\circ$  divergent angle.

The target current drops to one half of its peak value when the frequency changes are one part in  $3 \times 10^4$ . Therefore, because of frequency instability of the magnetrons and changes of mechanical dimensions of the cavities of the accelerator caused by power dissipation, etc., occasional tuning of the magnetron frequency is required for long exposure. However, this presents no particular difficulties.

Fast and slow neutrons, stray electrons with energy below 3 mev, and x-radiation of 5 mev effective energy were found to be stray radiation inside the treatment room when an electron beam of 30 mev was used. Lead shields of 2-inch thickness were installed so that the biological effect of the resultant total stray radiation is below one-thousandth of that of the useful beam.

Ionization-depth dose measurements in presdwod phantoms were made and some of the results agree with those published in experiments with betatrons,<sup>4</sup> as far as the extrapolated range is concerned. Observations that the ionization distribution strongly depends on the beam size indicate interesting possibilities for therapeutic applications.

Biological experiments are being carried out, the results of which will be reported later.

<sup>3</sup> Unanalyzed electron beam emerging from the accelerator itself.

<sup>4</sup> Laughlin, J. S., Ovadia, J., Beattie, J. W., Henderson, W. J., Harvey, R. A., and Haas, L. L.: Some Physical Aspects of Electron Beam Therapy, Radiology 60: 165-184, February 1953.

# EDITORIAL

---

---

## Dental Radiography

The art of radiographic interpretation is not something that can be learned as a result of a series of didactic lectures to which may be added some demonstrations. It requires a sound preliminary education in anatomy, pathology, and in the general principles of medicine and surgery. After this has been acquired, it is necessary that there be a thorough understanding of the basic principles of radiographic shadow production, both normal and abnormal. This takes years of constant application if there is to be even a moderate degree of skill in radiographic interpretation.

There is no branch of surgery and few branches of medicine in which radiographic interpretation is not of importance in diagnosis. Dentistry is no exception. Indeed, there is no field in which radiography is more necessary for diagnosis and treatment.

Who is responsible for the vast preponderance of dental radiographic studies? Are they individuals trained adequately to interpret the findings? The writer, who has for many years spent much time teaching dentists and students of dentistry the rudiments of radiographic interpretation, is forced to reply: "In general, no." There are, of course, exceptions to this statement, but they are relatively few.

The interpretation of dental radiographs is largely carried out by the dentists themselves, though a small proportion falls to the lot of the professional radiologist. Neither of these groups is adequately trained for the task. Dentists lack the understanding of the basic principles which are familiar to their radiological colleagues. They are also usually ill-trained in the general pathology of the jaws. Many radiologists as well have neglected to make themselves familiar with the pathological processes occurring in the teeth and jaws.

While x-ray apparatus is essential in most dental offices for the satisfactory performance of the mechanical and surgical procedures to be carried out, in the majority of cases its presence has not resulted in the same degree of skill in radiographic interpretation as is provided by radiologists examining other parts of the body.

What can be done to remedy this state of affairs? It is too much to expect that dental students shall take from their other studies sufficient time to achieve a firm understanding of basic radiological principles. This takes years, as every radiologist knows. Furthermore, an attempt to inculcate in these same students an adequate knowledge of the pathological conditions which may be found in the jaws is not likely to succeed, for several reasons. In most dental colleges or schools the incidence of any but the most common dental and periapical lesions is so low that there is little opportunity to demonstrate examples of the less common or grosser lesions. Even if such cases were available and the students were taught the characteristics of the more abnormal conditions, they would soon be forgotten, because they are so seldom encountered in practice.

In the writer's experience, most dentists and dental students are uninterested in any but purely local conditions which affect the teeth and the supporting structures. The result is that, when the average dentist encounters an abnormal lesion other than a periapical granuloma or abscess, or some such common entity, he either fails to recognize the presence of an abnormality or misinterprets its nature, so that a serious lesion may pass untreated until too late.

The responsibility for this state of affairs rests with the radiologists, who have been too uninterested to make the effort to ac-

quire added knowledge concerning purely dental abnormalities. Many of the gross lesions which occur in the jaws are found in other parts of the skeleton, and the fact of their location does not materially alter their radiographic appearance. The professional radiologist is familiar with these conditions or with the basic principles which enable them to be identified. The dentist is occupied in attaining knowledge and skills of a different character. It would be easier for the radiologist to learn dental radiology, which is after all governed by fundamental principles with which he is already familiar, as the dentist is not, nor can be expected to be.

Not until radiologists accept their responsibilities in this direction will dentists and the public obtain the degree of assistance from radiology that is now available in conditions involving other regions of the body.

It is perhaps not a justifiable criticism of the average dentist that he may mistake the normal antral shadow for a pathological process despite the absence of any clinical evidence of disease. Such an error may occur solely because he is not familiar with the multitudinous variations in the appearance of the air sinus.

Malignant tumors of the jaws are infrequently encountered in the average dental practice. Indeed, a dentist may go through the whole of his post-student career and not see one. Small wonder, therefore, that when the rare case does turn up, its malignant character is not suspected. The writer in one year encountered malignant tumors of the jaw in three patients who had been treated by the same dentist, without his having the slightest suspicion of the truth. Unusual certainly, and fortunately so! The radiologist, on the other hand, is likely to suspect malignancy in any tumor, wherever it may be found, but he is less likely to discriminate between a simple dental cyst and an adamanitoma which may resemble a cyst. Not a grievous error, but one that can have serious consequences. Again, normal tooth follicles often assume

pathological significance in the eyes of the radiologists, an error no dentist is likely to make.

Local lesions of purely dental origin, such as periapical osteofibrosis, are less prone to be identified by any but the dentist, although an experienced radiologist may be the one to inform the dentist that such a condition can exist.

Unless a radiologist has had the advantage of a dental training or has been closely associated with a dental school, he is not so likely to be able to follow the intricacies of some of the technical procedures which are a part of modern dentistry and which demand radiographic examinations at various stages in their process. These are better done in the dental office and are well within the capacity of the average dentist.

There would appear to be little doubt that between the imperfectly trained dentist, who cannot be expected to have the same knowledge of radiology as the professional radiologist, and the radiologist who neglects study of the jaws, or at most reads the section in a large textbook with no previous knowledge of dental pathology and of the principles of dental surgery, the patient fails to receive the advantages that he should have from our art.

It is doubtful that the radiological profession will assume its proper responsibility in this matter. Radiology is already a vast subject, and the actual making of good intra-oral radiographs presents difficulties to those who are not trained to work in the mouth; it is also time-consuming.

The function of making extra-oral radiographs is likely to remain with the radiologist, especially as tomograms and arthrograms may be required. Would it not therefore be more satisfying to him to take the trouble of adding to his intellectual armamentarium what is after all a very interesting subject? He would thereby enhance his service to his colleagues as well as to the patients who place themselves in the hands of the profession which is, or should be, one and indivisible.

HARRY M. WORTH, F.R.C.P. (C), L.D.S.

## ANNOUNCEMENTS AND BOOK REVIEWS

### GREATER ST. LOUIS SOCIETY OF RADIOLOGISTS

At a recent meeting of the Greater St. Louis Society of Radiologists, the following officers were elected: Dr. Francis O. Trotter, Jr., President; Dr. Charles J. Nolan, Vice-President; Dr. Edwin C. Ernst, Jr., 3720 Washington Ave., St. Louis 8, Secretary-Treasurer.

### PENNSYLVANIA RADILOGICAL SOCIETY

The Pennsylvania Radiological Society will hold its Fortieth Annual Meeting in the Berkshire Hotel, Reading, Penna., May 20 and 21. The program will include film-reading sessions, refresher courses on Radiology of the Heart and Great Vessels and Treatment Methods in Cancer of the Cervix, and papers covering various aspects of radiologic practice. Dr. Russell H. Morgan will deliver the William E. Reilly Lecture, on "Screen Intensification in Radiologic Diagnosis and Therapy."

For reservations, write the Berkshire Hotel, Reading, Penna.

### HONORS FOR DR. CASE AND DR. DEL REGATO

The President of the Republic of Cuba, at the proposal of the Minister of Public Health, has recently signed a decree awarding the National Order of Merit "Carlos J. Finlay," in the grade of officer, to Dr. James T. Case and Dr. Juan A. del Regato. This honor will be bestowed on the two recipients on the occasion of the Fifth Inter-American Congress of Radiology to be held in Washington, D. C., April 24 and 29. Dr. Case is President of the Congress, and Dr. del Regato, Secretary for Latin America.

### SECOND ANNUAL MEETING SOCIETY OF NUCLEAR MEDICINE

The Society of Nuclear Medicine will hold its Second Annual Meeting in the Multnomah Hotel, Portland, Ore., June 17-19, 1955. Included in the program will be papers dealing with all aspects of nuclear medicine, from basic research to clinical application.

In addition to individual papers there will be discussions on the uses of isotopes in medicine and evaluations of attainments in this field by a panel which will include, among others, Dr. Leon Jacobson (Chicago), Dr. Henry Jaffe (Los Angeles), and Dr. Edwin Osgood (Portland). The banquet speaker on Saturday evening, June 18, will be Dr. John Lawrence, director of the Donner Laboratories of the University of California.

For further information and for hotel reservations, address Charles P. Wilson, M.D., 2455 N. W. Marshall St., Portland 10, Ore.

### BROOKHAVEN SYMPOSIUM IN BIOLOGY

The Eighth Annual Summer Conference sponsored by the Biology Department of the Brookhaven National Laboratory, Upton, N. Y., will be held June 15-17, 1955. The theme of the conference is Mutation, and papers will be included on the effects of radiation on genetic material. Those planning to attend should notify Dr. R. C. King of the Brookhaven National Laboratory not later than May 21. Any who are not citizens of the United States should indicate their nationality.

### AMERICAN SOCIETY OF X-RAY TECHNICIANS

The American Society of X-Ray Technicians will hold its Twenty-seventh Annual Convention, May 29 to June 2, 1955, at the Hotel Statler, Boston, Mass.

### Books Received

Books received are acknowledged under this heading, and such notice may be regarded as recognition of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

**THE ABNORMAL PNEUMOENCEPHALOGRAM.** By LEO M. DAVIDOFF, M.D., Professor and Chairman, of the Department of Surgery of the Albert Einstein College of Medicine, and Director of Surgery, Bronx Municipal Hospital Center; Chief of Neurosurgery, Mount Sinai Hospital, New York, N. Y., and BERNARD S. EPSTEIN, M.D., Chief, Department of Radiology, The Long Island Jewish Hospital, New Hyde Park, N. Y. A volume of 518 pages, with 291 figures. Published by Lea & Febiger, Philadelphia. 2d ed., 1955. Price \$15.00.

**HYPERTOSTOSIS CRANII. STEWART-MOREL SYNDROME; METABOLIC CRANIOPATHY; MORGAGNI'S SYNDROME; STEWART-MOREL-MOORE SYNDROME (RITVO); LE SYNDROME DE MORGAGNI-MOREL.** By SHERWOOD MOORE, M.D., Professor Emeritus of Radiology, Washington University School of Medicine; Former Director of the Edward Mallinckrodt Institute of Radiology, St. Louis, Mo. A volume of 226 pages, with 107 illustrations and 7 tables. Published by Charles C Thomas, Springfield, Ill. Price \$10.50.

**X-RAY ATLAS AND MANUAL OF ESOPHAGUS, STOMACH AND DUODENUM.** By DR. T. J. J. H. MEUWISSEN, Consulting Physician and Radiologist

at Eindhoven (The Netherlands), with an Introduction by ROBERT D. MORETON, M.D., F.A.C.R., Radiologist at Fort Worth, Texas (U. S. A.). Edited by DR. G. C. F. BRINKBOK, Radiologist at Amsterdam, and translated by MAY HOLLANDER, Selborne (England). A volume of 688 pages, with 1,201 illustrations and 11 schematic drawings. Published by the Elsevier Press, Houston, Texas. Price \$25.00.

**DIAGNOSTIC PROCEDURES WITH RADIOISOTOPES.** An illustrated loose-leaf manual designed to provide a compact source of technical information on the use of radioisotopes in diagnostic procedures. Published by Abbott Laboratories, Department of Radioactive Pharmaceuticals, Chicago, Ill., and Oak Ridge, Tenn., 1955. No charge.

**AN ATLAS OF TUMOR PATHOLOGY.** Published by the Armed Forces Institute of Pathology, under the auspices of the Subcommittee on Oncology of the Committee on Pathology of the National Research Council, Washington, D. C. For sale by the American Registry of Pathology, Washington 25, D. C.

**TUMORS OF THE STOMACH.** Section VI, Fasc. 21. By ARTHUR PURDY STOUT, M.D., Professor of Pathology, Columbia University, College of Physicians and Surgeons, New York City. One hundred and four pages, with 66 illustrations. Price \$1.75.

**TUMORS OF THE RETROPERITONEUM, MESENTERY AND PERITONEUM.** Section VI, Fases. 23 and 24. By LAUREN V. ACKERMAN, M.D., Professor of Pathology and Surgical Pathology, Washington University School of Medicine; Surgical Pathologist for Barnes Hospital and Affiliated Hospitals, St. Louis, Mo. One hundred and thirty-six pages, with 105 illustrations. Price \$1.75.

**TUMORS OF THE SOFT TISSUES.** Section II, Fasc. 5. By ARTHUR PURDY STOUT, M.D., Professor of Pathology, Columbia University, College of Physicians and Surgeons, New York City. One hundred and thirty-eight pages, with 78 illustrations. Price \$1.75.

**TUMORS OF THE MAJOR SALIVARY GLANDS.** Section IV, Fasc. 11. By FRANK W. FOOTE, JR., M.D., Attending Pathologist, Memorial Center for Cancer and Allied Diseases, New York, N.Y.; Associate Diagnostic Pathologist, Division of Laboratories and Research, New York State Department of Health, Albany, N. Y., AND EDGAR L. FRAZELL, M.D., Associate Attending Surgeon, Memorial Center for Cancer and Allied Diseases, New York, N. Y. One hundred and forty-eight pages, with 184 illustrations. Price \$1.75.

**OPERATIVE CHOLANGIOGRAPHIE. TECHNIK, DIAGNOSTIK, PRAXIS.** By Priv.-Doz. Dr. Walter Hess, Oberarzt der Chirurg. Univ.-Klinik Basel, with a Foreword by Prof. Dr. R. Nissen, Direktor der Chirurg. Univ.-Klinik Basel. A volume of 202 pages, with 150 illustrations. Published by Georg Thieme Verlag, Stuttgart. Distributed in the United States and Canada by the Intercontinental Medical Book Corporation, New York 16, N. Y., 1955. Price DM 42.—(\$10.00).

**DIE BRONCHOGRAPHIE. Ergänzungsband 72, Fortschr. a. d. Geb. d. Röntgenstrahlen.** By DR. ERNST STUTZ, Dozent an der Universität Freiburg I. Br., and DR. HEINZ VIETEN, Dozent an der Medizinischen Akademie, Dusseldorf. A volume of 250 pages, with 181 illustrations. Published by Georg Thieme Verlag, Stuttgart, 1955. Distributed in the United States and Canada by the Intercontinental Medical Book Corporation, New York 16, N. Y. Price DM 66.—(\$15.70).

## Book Reviews

**CONGENITAL HEART DISEASE. AN ILLUSTRATED APPROACH.** By HENRY S. KAPLAN, M.D., Professor of Radiology, Stanford University School of Medicine, and SAUL J. ROBINSON, M.D., Assistant Clinical Professor of Pediatrics, Stanford University School of Medicine, Chief Department of Pediatrics, Mount Zion Hospital, San Francisco. A volume of 126 pages, with 146 illustrations. Published by McGraw-Hill Book Company, Inc., New York, 1954. Price \$12.50.

The scope and limitations of this new work on *Congenital Heart Disease* are stated in the authors' Preface. It is addressed to the general practitioner as a working handbook, a "brief, simple, and well illustrated description of the more common congenital cardiac defects," emphasizing the general diagnostic approach, with no attempt to encompass the entire subject.

Brief opening chapters on clinical evaluation and general laboratory procedures are followed by a chapter on the conventional roentgen examination, including an analysis of the cardiovascular silhouette in the standard projections and a description of the changes in contour with enlargement of various chambers. The concluding section of this chapter, on "provisional roentgen diagnosis", sets forth clearly the general categories of disease which are suggested by the appearance of the cardiac silhouette and pulmonary vessels in association with the presence or absence of cyanosis.

There is a chapter on the electrocardiogram and one on special procedures such as angiocardiology, aortography, and heart catheterization. The section on angiocardiology, in view of its increasing use, is definitely limited, though perhaps intentionally so, since the authors refer their readers else-

where for detailed consideration of both the technical and interpretive aspects.

In an Atlas, which constitutes about half the work, the features of the various congenital lesions are summarized under the following headings: anatomical features; circulatory dynamics; clinical features; radiological features; electrocardiographic features; laboratory findings; special diagnostic procedures of choice; surgical treatment. Facing the text are roentgenograms of the condition under consideration, in various projections reproduced in duplicate, with superimposed drawings of the cardiac chambers and great vessels on one set.

The descriptions of the films reproduced, with the diagnostic points, are in general excellent, though, as is so often the case, the reproductions themselves often leave some doubt as to the appearance of the pulmonary vessels of medium and smaller size. The work would be improved by the omission of an unproved case (page 104) which may have been either Lutembacher's disease or Eisenmenger's complex.

This book accomplishes the purpose for which it was written and supplies all the information on the subject which the average practitioner or pediatrician will want. The needs of the resident in radiology are also met, except as concerns angiocardiology. The book is recommended for these groups.

#### MEDICINA NUCLEARE. INTRODUZIONE ALLE APPLICAZIONI MEDICO-BIOLOGICHE DELLA FISICA NUCLEARE.

By ALDO PERUSSIA, with the collaboration of U. Facchini, E. Gatti, L. Malatesta, C. Salvetti, and M. Silvestri. Prefaces by Professors G. Bolla, F. Perussia, and P. Rondoni. A volume of 878 pages, with 143 figures and 23 tables. Published by Il Pensiero Scientifico Editore, Rome, 1954.

This volume of nearly 900 pages is the fruit of a collaboration between Prof. A. Perussia of the Institute of Radiology at the University of Milan and several well known scientists of the C.I.S.E. laboratories of the same city. It is addressed to the medical profession in general and to radiologists in particular, with the stated purpose of stimulating, more than satisfying, the reader's interest in the various topics treated therein. These are many and are gathered under four main headings preceded by an introduction.

The introduction describes in general terms the impact of nuclear physics on the biomedical sciences and discusses the practical factors to be considered in the establishment of well equipped centers competent to appraise it with experimental, clinical, and therapeutic endeavors.

Part I, of 113 pages, is entitled "General Theoretical and Technical Foundations," and is written by Gatti, Malatesta, Perussia, Salvetti, and Silvestri. It reviews in concise style and with didactic skill features of basic nuclear physics, radiobiology and radiation chemistry, as well as the more specialized fields of dosimetry, sources of radiation, reactors,

production and biological behavior of radioelements.

Part II, by Facchini, Gatti, and Perussia, devotes 94 pages to general instrumentation, namely principles, techniques and methodology of detection and measurements. It includes a fairly complete table on physical and dosimetric properties of most radionuclides of biomedical interest.

Part III, of almost equal length, is entitled "Radioactive Isotopes in Biological Research and Clinical Investigation," and is written by Perussia. It treats the basic mathematical features of tracer techniques in static and dynamic systems and reviews some of the applications to biological and medical research.

Part IV, also by Perussia, covers over 400 pages of text and it is entitled "Applications of Nuclear Physics to Radiotherapy." It is subdivided into five sections dealing with (a) basic general radiotherapy and classical radiotherapeutic methods (28 pages); (b) external radiotherapy with high energy radiation—prospects on the therapeutic use of neutrons (80 pages); (c) applications of artificial radioactivity to therapy as an extension of classical methods (63 pages); (d) internal radiation therapy with artificial radioisotopes (214 pages); (e) biological hazards of ionizing radiations and their control in professional exposure. An informative table of radioisotopes and a general bibliography close this chapter and the volume.

In the accuracy of its contents and in the order of presentation, this book amply demonstrates the care and the extent of the effort employed in producing it. The active research worker may query the want of bibliographic detail, and the senior radiotherapist may find the lack of detailed tissue dosimetry unsuitable to the daily needs of his practice. These shortcomings have been foreseen by the principal author and could not be avoided in such a wide coverage. However, the student of radiology and the busy medical investigator should find the work just about ideal as a general introduction, and as a cultural guide to the subject. Since it is devoid of complicated mathematical treatment, it should make easy and pleasant reading. Medical officers charged with decisions of initiating activities in this field, with restricted budgets and conflicting interests within their institutions, should find the comments in Part IV useful food for thought and most helpful in appraising the situation that may confront them.

#### DIAGNOSTICA RADILOGICA E TERAPIA FISICA IN ODONTOIATRIA. By GIOVANNI SMERCHINICH, già insegnante di radiologia nella Scuola di specializzazione in odontoiatria dell' Università di Milano.

A monograph of 330 pages, with 760 illustrations. Published by Ulrico Hoepli, Milan, 1954. Price Lire 3,500.

This book represents a complete study of the various uses of x-ray in dental practice. The author

begins by mentioning the various forms of radiant energy, with special attention to the roentgen rays, and describes x-ray machines and technical factors. The normal appearance of the teeth, the upper and lower jaws, the nose, and sinuses are discussed in detail. The next few chapters are given to a description of the deciduous and permanent dentition, to the pathology of dentine, to periodontal and para-dental diseases, to osteomyelitis, cystic formations, tumors, and differential diagnosis. Other chapters cover traumatic changes, the temporomandibular joints, orthopedic operations, the radiological examination of patients with facial pain, radiological findings in diseases originating elsewhere in the body, and dental radiological findings in endocrine disturbances. A chapter describes the employment of roentgen rays in dental therapy and another is devoted to diathermy. A good index completes the book.

The volume is well printed, and the illustrations are well chosen and clearly reproduced. The author has covered his subject quite thoroughly and the text should be valuable for those who are interested in oral surgery and dentistry and who are familiar with the Italian language.

DIE BEDEUTUNG DES BLUTCHEMISMUS. BESONDERS IN BEZIEHUNG ZU TUMORBILDUNG UND TUMORABBAU. (DER ZELL- UND GEWEBSSTOFFWECHSEL ALS INNERE KRANKHEITSBEDINGUNG. II TEIL). By Prof. DR. ERNST LEUPOLD, Direktor des pathologischen Instituts der Universität Köln. A monograph of 205 pages, with 102 illustrations and 116 tables. Published by Georg Thieme Verlag, Stuttgart, 1954. Distributed by Intercontinental Medical Book Corp., New York, 16 N. Y. Price \$11.90.

The impressive title "The Significance of the Blood Chemistry: Particularly in Connection with Tumor Formation and Tumor Destruction" introduces a hodgepodge of nonsense which could be ignored if it did not include a recommendation for a cancer treatment that, should it appear unforewarned and in the hands of the unscrupulous, could be dangerous.

Leupold's premise that the environment of the cells is the body fluid is an established notion. When he carries the statement farther, to the effect that any disturbance of the body fluid disturbs all

the cells and conversely that any local cellular disturbance alters all of the body fluid and thus all of the body cells, he still appears logical. But then (on page 31) he describes his experiment on rabbit K 825. On March 17, 1950, he injected 0.05 c.c. of 5 per cent aqueous glycocoll subcutaneously into the ear of this rabbit. On May 5, the animal died. Autopsy revealed a sarcoma involving the spleen, the kidney, and other viscera. *Post hoc ergo propter hoc*: the injection caused the tumor. In this same manner in additional animals small quantities of various simple organic compounds are alleged to have produced tumors of numerous sorts.

Tumor growth and recession are followed with studies on the blood serum. Great significance is given to the interrelationship of the blood sugar, lipoid phosphorus, and cholesterol. These chemicals are reputed to vary both on injection of tiny doses of ordinarily innocuous substances and with the control of a tumor when the tumor is treated. The following is a translation, as literal as possible, from page 179, on the management of a carcinoma of the breast of a 34-year old woman. The blood withdrawals mentioned were made to determine the sugar, lipoid phosphorus, and cholesterol. A cure is claimed in this instance here and in other similarly managed cases.

"The plan of management is as follows:

- "1. Blood withdrawal, 15 to 20 grams of grape sugar iv, blood withdrawal, 0.05 c.c. of ionic fat mixture, after half an hour 20 units of old insulin.
- "2. Upon the onset of hypoglycemic symptoms (as a rule after one and a half to two hours) blood withdrawal, 10 grams of grape sugar iv, blood withdrawal.
- "3. Upon the onset of a light hypoglycemic reaction (as a rule after one hour) 5 grams of grape sugar iv, blood withdrawal.
- "4. After about an hour one more blood withdrawal."

Were the paucity of references noticed, and were this work not on fine quality paper, well bound, and well illustrated, one could easily dismiss the above treatment as pishposh. Since the presentation does at times seem plausible, American physicians should alert themselves that they be not misled.

## IN MEMORIAM

---

### Leon J. Menville, M.D.

1882-1955

The death of Dr. Leon J. Menville on Jan. 24, 1955, took from us a striking personality, an ideal physician, a distinguished teacher, an investigator in fertile fields of inquiry, a contributor of important scientific essays, a commanding figure in modern radiology and current medical affairs, and a delightful companion.

Dr. Menville was born in Napoleonville, La., on Nov. 29, 1882, the son of a country doctor in the sugar cane parishes of Louisiana. His early education was obtained in private and public schools in Pointe Coupee Parish and in Houma. He received his undergraduate training at Louisiana State University and his medical degree from Maryland Medical College, Baltimore, in 1904. Upon his graduation, he joined his father, Dr. Charles M. Menville, in the practice of medicine in Houma. One of his early investments was \$75 for a horse and \$50 for a buggy. The horse, at one time the property of a plantation overseer, cost its new owner some embarrassing moments. Returning from calls, along a muddy road, far down a bayou, he was likely to be hailed by a friendly worker in the fields, whereupon the animal, true to its early training, would come to an abrupt stop, waiting, as in the old days, for his master to call out instructions before consenting to go on.

To familiarize himself more fully with the appearance of the malarial parasite and with the making of blood counts, Dr. Menville early sought the help of Dr. William H. Harris, Sr., a member of the Department of Pathology at Tulane University, and through his kindness was permitted to study various microscopic slides. Some of these slides were brought back to Houma for further observation by the young doctor, who later purchased equipment and constructed a wooden laboratory stand and sink so that he might carry out blood studies and gastric analyses.

Father and son played a valiant part in the last yellow fever epidemic in Louisiana in 1905. In this same year, becoming interested in the roentgen rays discovered nine years previously, they purchased one of the early x-ray machines, which they soon were able to operate.

Dr. Menville continued happily in general practice with his father for a period of thirteen years, but the art of radiology soon became his chief interest. After graduate studies in this field, at the Mayo Clinic, Dr. Menville in 1918 entered practice in New Orleans as the associate of Dr. George S. Bel, Professor of Medicine at Tulane University. He was soon recognized as an outstanding radiolo-

gist, and at the time of his death was internationally known. He was, indeed, "one of the men who helped make New Orleans famous as a medical center." For many years he had offices in that city with his friend and partner, Dr. Joseph V. Hopkins, Jr.

In 1919, Dr. Menville was appointed to the faculty of the Tulane University School of Medicine as an instructor; later he became Assistant Professor and, in 1934, Professor of Radiology, which position he held until his retirement in 1948, when he was made Emeritus Professor.

Dr. Menville served as Chief of the Department of Radiology in the Hutchinson Memorial Clinic of Tulane University. For ten years he was Director of the Department of Radiology of Charity Hospital of Louisiana, New Orleans, and in addition was radiologist at the Presbyterian, French, and Illinois Central Hospitals, Consultant at Hotel Dieu, Flint-Goodridge Hospital of Dillard University in New Orleans, and the U. S. Veterans Hospital in Algiers.

Dr. Menville became a member of the Radiological Society of North America in 1920, and served on various committees and as Vice-President on two occasions. He succeeded Dr. Maximilian J. Hubeny as Editor of *RADIOLOGY* in 1931 and continued to serve in that capacity, with distinction, until 1941, when he became President-Elect of the Society. His editorship was not without its difficulties, for it included periods of inflation and deflation, each with its peculiar problems. Both of these were successfully weathered under Dr. Menville's leadership, and on his retirement from the editorship to accept the presidency of the Society he left a journal well established and universally recognized as one of the outstanding radiological publications of the world. In 1953, the Society accorded Dr. Menville a citation and elected him to honorary life membership, an honor previously conferred upon only eight other men, each of whom had attained national prominence in the field of radiology.

Dr. Menville served on the Editorial Board of the *American Journal of Cancer*, was Chairman of the Journal Committee of the *New Orleans Medical and Surgical Journal*, was past Vice-President of the American College of Radiology, and represented the Radiological Society of North America on the first examining board of the American Board of Radiology. He was a fellow and Executive Vice-Chairman, Section on Radiology, of the American Medical Association and was a delegate to that body, representing the Louisiana State Medical Society.



LEON J. MENVILLE, M.D.  
Editor of Radiology 1931-1941

He held membership in the American Roentgen Ray Society, the American Radium Society, Society of Experimental Biology and Medicine, Southern Medical Association, Orleans Parish Medical Society, Louisiana State Radiological Society, and Louisiana State Medical Society. This last organization he served as President, that honor having followed five successive terms as Chairman of the House of Delegates.

For many years, Dr. Menville was a member of the State Board of Medical Examiners. He was a firm believer in the value of organized medicine and he and his colleagues were active in clearing his State of Quacks. During his years as President of the Louisiana State Board of Medical Examiners much constructive work was accomplished, including an exemplary Medical Practice Act.

Dr. Menville represented the United States as a delegate to the First Inter-American Congress of Radiology in Buenos Aires, and later as a delegate to the Congress at its meeting in Havana, in 1946. Honorary membership was bestowed upon him by the Radiological Society of Cuba. He also was a corresponding and honorary member of the National Academy of Medicine of the Republic of Colombia.

Dr. Menville was author of more than forty medical articles and contributed to such textbooks as Pillmore's *Clinical Radiology* and Pohle's *Clinical Radiation Therapy*. He received the Gold Medal of the Radiological Society of North America in 1932, and the Gold Medal of the Louisiana Academy of Sciences in 1934 for his original studies on the roentgen visualization of the lymphatic system. He and an associate, Dr. Joseph N. Ané, were the first men in history to see the lymph system of a living animal demonstrated on the roentgenogram. Outstanding also was his experimental work on the emptying of the visualized gallbladder, the motility of the gastrointestinal tract, and the absorbability of x-rays by salts of various metals.

In World War I, Dr. Menville served as First Lieutenant at Camp Stafford, as a member of a Board studying tuberculosis. In 1928 he was commissioned Lt. Commander, U. S. Naval Reserve, and served for many years as Consultant in Roentgenology at the U. S. Veterans Hospital No. 84, Algiers, La. During World War II, he was a member of the Selective Service Board.

Dr. Menville was a member of Omicron Delta Kappa and of Alpha Omega Alpha, honorary

medical fraternities, and of Phi Chi and Sigma Xi fraternities. He was a charter member of the Knights of Columbus at Houma, where he was a Grand Knight and Fourth Degree member. He also held membership in the Chess, Checkers and Whist Club and in the Pickwick Club.

There can be no doubt but Dr. Menville's life was influenced by the character of his parents and the circumstances of his childhood and youth. From his parents he learned steadfastness, sincerity, and the value of thinking a problem through to its end simply and clearly. One example set by his father, which he continued to follow, was the Old World tradition of never sending a widow a bill. From his humane personality as well as from his skill as a diagnostician, his patients drew strength and courage. His life should be an inspiration, particularly to the younger radiologists. He had that rare trait, curiosity, which impelled him to seek an explanation for any unusual observations. No one who was associated closely with him is likely to forget the immensely stimulating influence of such contact. His teaching was a liberal education and his personal reminiscences of the pioneer days of radiology endeared him to his students and colleagues. His charm of person and wealth of mind were well known to his family and intimates. Dr. Menville's "family story," which he was dictating at home for his family during the last year of his life, will be of great interest to all who knew him. To convey even an imperfect idea of all that Leon Menville meant in the lives of his associates is no easy task, but he is enshrined in our hearts as a well beloved friend.

Dr. Menville is survived by his wife, the former Miss Marie Marmande; two daughters, Mrs. Robert Dupont of Houma and Mrs. William M. Allin of West Newton, Mass.; a son, Dr. John G. Menville of New Orleans; a brother, Felix Menville of Houma, and a sister, Mrs. Eugene Fortier of New Orleans.

Our deepest sympathy goes to those he has left behind. We will never forget our professional comrade.

"The heights by great men reached and kept  
Were not attained by sudden flight,  
But they, while their companions slept,  
Were toiling upward in the night."

EUGENE P. PENDERGRASS, M.D.

## Lewis Gregory Cole, M.D.

1874-1954

To the date of his death in October 1954, in his eighty-first year, Lewis Gregory Cole remained a disciple of science. The unfolding of knowledge concerning the cause and mechanism of disease always fascinated him. Tentative diagnosis made him unhappy; the search for new methods of precision was his delight.

Dr. Cole was born in Lake Mahopac, N. Y., in 1874 of pioneer stock. At fifteen his education was considered complete. In 1887 he was employed in a wholesale shoe store at five dollars a week, with promise of an annual raise of a dollar a week. Five years were spent thus with little thought of the future. However, during the depression of 1893, when it was announced that he was the only employee to receive the coveted salary increase, he made the first important decision of his life: to study medicine.

The College of Physicians and Surgeons of New York then required one year of college credits. For three months young Lewis Cole devoted his after-working hours to study, and in March of 1894 he took the entrance examinations but failed. His determination held fast, however, and he stopped work to enroll in the New York Preparatory School. Having met the entrance requirements in June, he became the first student to register in the College of Physicians and Surgeons under the four-year curriculum. To meet necessary expenses he borrowed money from his brother-in-law, and to save carfare he rode a bicycle from his home in Brooklyn to 59th Street, a daily round trip of three hours. He served his internship at Roosevelt Hospital, New York, and there acquired a special interest in fractures and traumatic conditions, which was destined to influence his life work.

In 1899, Dr. Cole entered general medical and surgical practice. When assisting at an operation for an infected compound fracture of the leg that did not unite properly, he arranged for an x-ray examination. Since Roosevelt Hospital had no x-ray facilities, the patient was taken in a horse-drawn ambulance to Hudson City Hospital, where the apparatus was located in the engine room, with the chief engineer as the radiologist. It was necessary to wait until after nightfall to develop the plates, as there were no dark-room facilities. Vexed by the angulation the x-rays indicated, and knowing that he had followed closely his teaching, Dr. Cole became skeptical and proceeded in an attempt to prove or disprove the usefulness of x-rays. This experience became the basis for his first contribution to radiology, a paper entitled "Skiagraphic Errors: Their Causes, Dangers, and Prevention." About this time, also, he sought to advance the technic for pyelography, using first air and then opaque material.

Dr. Cole was probably the first to advocate the use of x-rays in the diagnosis of tuberculosis of the lung. Since the medical profession did not share his enthusiasm for this new procedure, he undertook to establish a scientific basis for his convictions. For this, he needed specimens for x-ray research. Having an intimate friend who was Assistant Professor of Pathology at his Alma Mater, he asked to borrow two lungs which had been used for demonstration purposes and for which there was no further need. Not only was his request refused, but the supposed friend called Dr. Cole a charlatan, a disgrace to the medical profession and to his family, and even ordered him out of his office.

While deeply depressed by this episode, Dr. Cole resolved to continue with this research. Later he gained permission from the morgue at Bellevue Hospital to inflate lungs for study, and this work became the basis for an exhibit at the International Congress on Tuberculosis at Cincinnati in 1907. Medical colleagues now began referring cases to him, and he was permitted by Dr. Trudeau to install the first x-ray apparatus at the Saranac Lake Sanatorium.

In 1909 Dr. Cole devised a special table (the Cole table) for the diagnosis of duodenal ulcer. With this, he developed the direct method for accurate and reliable diagnosis of duodenal ulcer in contrast to the indirect method advanced by the Viennese school that believed the symptom complex based on the history, the physical findings, gastric analysis, and fluoroscopic studies offered the only diagnostic criteria. Dr. Cole's first paper on the multiple plate method for direct visualization of the ulcer, presented before the American Medical Association in 1912, opened a new epoch in this field of diagnosis. Opposition received at this time would have overwhelmed a less courageous scientist, but with the years the wisdom of his work has been acknowledged.

A ten-year period was devoted to the study of the differential diagnosis of gastric ulcer and cancer. Cole's conclusions, presented in book form, were not received favorably, especially by the pathologists. However, there is no doubt but that this treatise did much to clarify difficulties in differentiating simple gastric ulcer from ulcerative gastric carcinoma. Another ten years he devoted to investigating the effect of dust inhalation in the lungs, much of the time as Director of Silicotic Research of the John C. Pierce Foundation. Data of a basic character were obtained which have proved useful in social and industrial problems and in legislation relating to this subject.

Among Dr. Cole's contributions to the literature are two textbooks, contributions to other texts, and more than a hundred articles in medical journals.



LEWIS GREGORY COLE, M.D.

He believed that some of his best contributions were refused publication because they were considered too radical for the times. *Fifty Fighting Years*, his last writing, is now being edited for publication.

Dr. Cole was awarded the Gold Medal of the Radiological Society of North America in 1921, the first James Ewing Award, and the fourth Friedenwald Medal from the American Gastroenterological Society. Further testimony to his unique position were numerous community activities, military service, hospital staff appointments, medical faculty status, fellowships and memberships on local, national, and international levels, in both medical and radiological organizations.

This account cannot include all the accomplishments of a lifetime characterized by sustained in-

terest, enthusiasm, and a truly scientific mind that swayed, revamped, and broadened the thinking of so great a number of medical teachers and radiological students. Know-how, coupled with confidence and tenacity, enabled Dr. Cole to meet difficult problems and assignments. This trait was never more evident than when he, with his son, Dr. William Gregory Cole, mastered the problem of preparing all scientific contributions for synchronous presentation in three languages at the 5th International Congress of Radiology in 1937.

Lewis Gregory Cole forged his way through many and adverse situations to win the acclaim of American medicine as a pioneer, an independent thinker, and a great radiologist.

B. H. ORNDOFF, M.D.

---

## RADIOLOGICAL SOCIETIES: SECRETARIES AND MEETING DATES

*Editor's Note:* Secretaries of state and local radiological societies are requested to co-operate in keeping this section up-to-date by notifying the editor promptly of changes in officers and meeting dates.

**RADIOLOGICAL SOCIETY OF NORTH AMERICA.** *Secretary-Treasurer*, Donald S. Childs, M.D., 713 E. Genesee St., Syracuse 2, N. Y.

**AMERICAN RADIUM SOCIETY.** *Secretary*, Robert E. Fricke, M.D., Mayo Clinic, Rochester, Minn.

**AMERICAN ROENTGEN RAY SOCIETY.** *Secretary*, Barton R. Young, M.D., Germantown Hospital, Philadelphia 44, Penna.

**AMERICAN COLLEGE OF RADIOLOGY.** *Exec. Secretary*, William C. Stronach, 20 N. Wacker Dr., Chicago 6.

**SECTION ON RADIOLOGY, A. M. A.** *Secretary*, Paul C. Hodges, M.D., 950 East 59th St., Chicago 37.

### Alabama

**ALABAMA RADIOLOGICAL SOCIETY.** *Secretary-Treasurer*, J. A. Meadows, Jr., M.D., Medical Arts Bldg., Birmingham 5.

### Arizona

**ARIZONA RADIOLOGICAL SOCIETY.** *Secretary-Treasurer*, R. Lee Foster, M.D., 507 Professional Bldg., Phoenix. Annual meeting with State Medical Association; interim meeting in December.

### Arkansas

**ARKANSAS RADIOLOGICAL SOCIETY.** *Secretary*, Joe A. Norton, M.D., 843 Donaghey Bldg., Little Rock. Meets every three months and at meeting of State Medical Society.

### California

**CALIFORNIA MEDICAL ASSOCIATION, SECTION ON RADIOLOGY.** *Secretary*, H. R. Morris, M.D., 1027 D St., San Bernardino.

**EAST BAY ROENTGEN SOCIETY.** *Secretary*, Dan Tucker, M.D., 434 30th St., Oakland 9. Meets monthly, first Thursday, at Peralta Hospital.

**LOS ANGELES RADIOLOGICAL SOCIETY.** *Secretary*, Oscar Harvey, M.D., 3741 Stocker St., Los Angeles 8. Meets monthly, second Wednesday, Los Angeles County Medical Association Bldg.

**NORTHERN CALIFORNIA RADIOLOGICAL CLUB.** *Secretary*, H. B. Stewart, Jr., M.D., 2920 Capitol Ave., Sacramento. Meets last Monday of each month, September to May.

**PACIFIC ROENTGEN SOCIETY.** *Secretary*, L. Henry Garland, M.D., 450 Sutter St., San Francisco 8. Meets annually at time of California State Medical Association convention.

**RADIOLOGICAL SOCIETY OF SOUTHERN CALIFORNIA.** *Secretary-Treasurer*, George Jacobson, M.D., Box 146, 1200 N. State St., Los Angeles 33.

**SAN DIEGO RADIOLOGICAL SOCIETY.** *Secretary*, C. W. Bruner, M.D., 2456 Fourth Ave., San Diego 1. Meets first Wednesday of each month.

**SAN FRANCISCO RADIOLOGICAL SOCIETY.** *Secretary*, Tom M. Fullenlove, M.D., 110 El Verano Way, San Francisco 27. Meets quarterly, at Grison's Steak House.

**SOUTH BAY RADIOLOGICAL SOCIETY.** *Secretary*, Herbert R. Berman, M.D., 309 St. Claire Bldg., San Jose. Meets monthly, second Wednesday.

**X-RAY STUDY CLUB OF SAN FRANCISCO.** *Secretary*, James T. English, M.D., 2000 Van Ness Ave., San Francisco 9. Meets third Thursday at 7:45, Lane Hall, Stanford University Hospital.

### Colorado

**COLORADO RADIOLOGICAL SOCIETY.** *Secretary*, Stuart A. Patterson M.D., Larimer County Hospital, Fort Collins. Meets monthly, third Friday, at University of Colorado Medical Center or Denver Athletic Club.

### Connecticut

**CONNECTICUT STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY.** *Secretary-Treasurer*, William A. Goodrich, M.D., 85 Jefferson St., Hartford 14. Meets bimonthly, second Wednesday.

### District of Columbia

**RADIOLOGICAL SECTION, DISTRICT OF COLUMBIA MEDICAL SOCIETY.** *Secretary*, John A. Long, M.D., 1801 K St., N.W., Washington 6. Meets third Wednesday, January, March, May, and October, at 8:00 P.M., in Medical Society Library.

### Florida

**FLORIDA RADIOLOGICAL SOCIETY.** *Secretary-Treasurer*, James T. Shelden, M.D., Box 1021, Lakeland. Meets in April and in October.

**GREATER MIAMI RADIOLOGICAL SOCIETY.** *Secretary-Treasurer*, André S. Capi, M.D., 300 N. 20th Ave., Hollywood, Fla. Meets monthly, third Wednesday, 8:00 P.M.

**NORTH FLORIDA RADIOLOGICAL SOCIETY.** *Secretary-Treasurer*, Ivan Isaacs, M.D., 1645 San Marco Blvd., Jacksonville 7. Meets quarterly, March, June, September, and December.

### Georgia

**ATLANTA RADIOLOGICAL SOCIETY.** *Secretary-Treasurer*, Albert A. Rayle, Jr., M.D., 490 Peachtree St. Meets second Friday, September to May.

**GEORGIA RADIOLOGICAL SOCIETY.** *Secretary-Treasurer*, Herbert M. Olinick, M.D., 417 Persons Bldg., Macon, Ga. Meets in November and at the annual meeting of the State Medical Association.

**RICHMOND COUNTY RADIOLOGICAL SOCIETY.** *Secretary*, Wm. F. Hamilton, Jr., M.D., University Hospital, Augusta. Meets first Thursday of each month.

**Hawaii**

**RADIOLOGICAL SOCIETY OF HAWAII.** *Secretary, H. C. Chang, M.D., 1282 Emma St., Honolulu 13.* Meets third Monday of each month.

**Illinois**

**CHICAGO ROENTGEN SOCIETY.** *Secretary, R. Burns Lewis, M.D., 670 N. Michigan Ave., Chicago 11.* Meets at the University Club, second Thursday of October, November, January, February, March, and April at 8:00 P.M.

**ILLINOIS RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, Stephen L. Casper, M.D., Physicians and Surgeons Clinic, Quincy.*

**ILLINOIS STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY.** *Secretary, George E. Irwin, Jr., M.D., 427 N. Main St., Bloomington.*

**Indiana**

**INDIANA ROENTGEN SOCIETY.** *Secretary-Treasurer, John A. Robb, M.D., 238 Hume-Mansur Bldg., Indianapolis 4.* Meets twice a year, first Sunday in May and during fall meeting of State Medical Association.

**TRI-STATE RADIOLOGICAL SOCIETY (Southern Indiana, Northwestern Kentucky, Southeastern Illinois).** *Secretary-Treasurer, Stephen N. Tager, M.D., 219 Walnut St., Evansville 9, Ind.* Meets last Wednesday, October, January, March, and May, 8:00 P.M., at the Elks' Club, Evansville, Ind.

**Iowa**

**IOWA RADIOLOGICAL SOCIETY.** *Secretary, James T. McMillan, M.D., 1104 Bankers Trust Bldg., Des Moines.* Meets during annual session of State Medical Society, and in the Fall.

**Kansas**

**KANSAS RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, G. S. Ripley, Jr., M.D., West Iron Ave., Salina.* Meets in the Spring with the State Medical Society and in the Winter on call.

**Kentucky**

**KENTUCKY RADIOLOGICAL SOCIETY.** *Secretary, David Shapiro, M.D., Jewish Hospital, 217 E. Chestnut St., Louisville 6.* Meets monthly, second Friday, at Seelbach Hotel, Louisville.

**Louisiana**

**ORLEANS PARISH RADIOLOGICAL SOCIETY.** *Secretary, Joseph V. Schlosser, M.D., Charity Hospital of Louisiana, New Orleans 13.* Meets second Tuesday of each month.

**RADIOLOGICAL SOCIETY OF LOUISIANA.** *Secretary-Treasurer, J. T. Brierre, M.D., 700 Audubon Bldg., New Orleans.*

**SHREVEPORT RADIOLOGICAL CLUB.** *Secretary, W. R. Harwell, M.D., 608 Travis St.* Meets monthly September to May, third Wednesday.

**Maine**

**MAINE RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, Walter A. Russell, M.D., Augusta General Hospital, Augusta.* Meets in June, October, December, and April.

**Maryland**

**BALTIMORE CITY MEDICAL SOCIETY, RADIOLOGICAL SECTION.** *Secretary-Treasurer, Paul W. Roman, M.D., 1810 Eutaw Place, Baltimore 17.* Meets third Tuesday, September to May.

**MARYLAND RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, Paul W. Roman, M.D., 1810 Eutaw Place, Baltimore 17.*

**Michigan**

**DETROIT X-RAY AND RADIUM SOCIETY.** *Secretary, E. F. Lang, M.D., Harper Hospital, Detroit 1.* Meets first Thursday, October to May, at Wayne County Medical Society club rooms.

**Minnesota**

**MINNESOTA RADIOLOGICAL SOCIETY.** *Secretary, John R. Hodgson, M.D., The Mayo Clinic, Rochester.* Meets in Spring and Fall and at annual meeting of State Medical Association.

**Mississippi**

**MISSISSIPPI RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, James M. Packer, M.D., 621 High St., Jackson.* Meets monthly, on third Tuesday, at 6:30 P.M., at the Hotel Edwards, Jackson.

**Missouri**

**RADIOLOGICAL SOCIETY OF GREATER KANSAS CITY.** *E. H. Stratemeier, Jr., M.D., 1010 Rialto Bldg., Kansas City, Mo.* Meets last Friday of each month.

**ST. LOUIS SOCIETY OF RADIOLOGISTS.** *Secretary, Edwin C. Ernst, Jr., M.D., 3720 Washington Ave., St. Louis 8.* Meets on fourth Wednesday, October to May.

**Montana**

**MONTANA RADIOLOGICAL SOCIETY.** *Secretary, Grant P. Raitt, M.D., 413 Medical Arts Bldg., Billings.* Meets annually.

**Nebraska**

**NEBRASKA RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, James F. Kelly, Jr., M.D., 816 Medical Arts Bldg., Omaha.* Meets third Wednesday of each month at 6 P.M. in Omaha or Lincoln.

**New England**

**CONNECTICUT VALLEY RADIOLOGICAL SOCIETY.** *Secretary, B. Bruce Alicandri, M.D., 20 Maple St., Springfield, Mass.* Meets second Friday of October and April.

**NEW ENGLAND ROENTGEN RAY SOCIETY.** *Secretary, Stanley M. Wyman, M.D., Massachusetts General Hospital, Boston 14.* Meets monthly on third Friday, October through May, at the Hotel Commander, Cambridge, Mass.

**New Hampshire**

**NEW HAMPSHIRE ROENTGEN SOCIETY.** *Secretary, Albert C. Johnston, M.D., 127 Washington St., Keene.*

**New Jersey**

**RADIOLOGICAL SOCIETY OF NEW JERSEY.** *Secretary, Carye-Belle Henle, M.D., 195 N. 7th St., Newark. Meets at Atlantic City at time of State Medical Society and midwinter in Elizabeth.*

**New York**

**BUFFALO RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, Clayton G. Weig, M.D., 135 Linwood Ave., Buffalo. Meets second Monday, October to May.*

**CENTRAL NEW YORK ROENTGEN SOCIETY.** *Secretary, Dwight V. Needham, M.D., 608 E. Genesee St., Syracuse 2. Meets in January, May, and October.*

**KINGS COUNTY RADIOLOGICAL SOCIETY.** *Secretary, Solomon Maranov, M.D., 1450 51st St., Brooklyn 19. Meets fourth Thursday, October to April (except December), at 9:00 P.M., Kings County Medical Bldg.*

**NASSAU RADIOLOGICAL SOCIETY.** *Secretary, Alan E. Baum, M.D., Hicksville, N. Y. Meets second Tuesday, February, April, June, October, and December.*

**NEW YORK ROENTGEN SOCIETY.** *Secretary, Sidney Rubenfeld, M.D., 477 First Ave., New York 16.*

**NORTHEASTERN NEW YORK RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, Donald H. Baxter, M.D., Albany Hospital, Albany. Meets in the capital area second Wednesday, October, November, March, and April. Annual meeting in May or June.*

**RADIOLOGICAL SOCIETY OF NEW YORK STATE.** *Secretary-Treasurer, Mario C. Gian, M.D., 610 Niagara St., Buffalo. Meets annually with the State Medical Society.*

**ROCHESTER ROENTGEN-RAY SOCIETY.** *Secretary-Treasurer, Charles E. Sherwood, M.D., 260 Crittenden Blvd., Rochester. Meets at Strong Memorial Hospital, 8:15 P.M., last Monday of each month, September through May.*

**WESTCHESTER RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, Maynard G. Priestman, M.D., New Rochelle Hospital, New Rochelle, N. Y. Meets third Tuesday of January and October and at other times as announced.*

**North Carolina**

**RADIOLOGICAL SOCIETY OF NORTH CAROLINA.** *Secretary, Waldemar C. A. Sternbergh, M.D., 1400 Scott Ave., Charlotte 2. Meets in April and October.*

**North Dakota**

**NORTH DAKOTA RADIOLOGICAL SOCIETY.** *Secretary, Marianne Wallis, M.D., Minot. Meets in the Spring with State Medical Association; in Fall or Winter on call.*

**Ohio**

**OHIO STATE RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, M. M. Thompson, Jr., M.D., 318 Michigan St., Toledo.*

**CENTRAL OHIO RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, Arthur R. Cohen, M.D., 41 S. Grant Ave., Columbus. Meets second Thursday October, November, February, April, and June, 6:30 P.M., Fort Hayes, Hotel Columbus.*

**CLEVELAND RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, H. F. Inderlied, M.D., 11311 Shaker Blvd., Cleveland 4. Meets at 6:45 P.M. on fourth Monday, October to April, inclusive.*

**GREATER CINCINNATI RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, Wm. R. Dickens, M.D., Cincinnati General Hospital, Cincinnati 29. Meets first Monday of each month, September to June, at Cincinnati General Hospital.*

**MIAMI VALLEY RADIOLOGICAL SOCIETY.** *Secretary, W. S. Koller, M.D., 60 Wyoming St., Dayton. Meets monthly, second Friday.*

**Oklahoma**

**OKLAHOMA STATE RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, John R. Danstrom, M.D., Medical Arts Bldg., Oklahoma City.*

**Oregon**

**OREGON RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, Fred C. Shipps, M.D., 214 Medical-Dental Bldg., Portland 5. Meets monthly, second Wednesday, October to June, at 8:00 P.M., University Club, Portland.*

**Pacific Northwest**

**PACIFIC NORTHWEST RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, J. Richard Raines, M.D., 214 Medical-Dental Bldg., Portland 5, Ore. Meets annually in May.*

**Pennsylvania**

**PENNSYLVANIA RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, James M. Converse, M.D., 416 Pine St., Williamsport 8. Meets annually.*

**PHILADELPHIA ROENTGEN RAY SOCIETY.** *Secretary, Herbert M. Stauffer, M.D., Temple University Hospital, Philadelphia 40. Meets first Thursday of each month at 5:00 P.M., from October to May, in Thompson Hall, College of Physicians.*

**PITTSBURGH ROENTGEN SOCIETY.** *Secretary-Treasurer, Donald H. Rice, M.D., 4800 Friendship Ave., Pittsburgh 24. Meets monthly, second Wednesday, at 6:30 P.M., October to May, at the Hotel Roosevelt.*

**Rocky Mountain States**

**ROCKY MOUNTAIN RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, John H. Freed, M.D., 4200 East Ninth Ave., Denver 7, Colo.*

**South Carolina**

**SOUTH CAROLINA RADIOLOGICAL SOCIETY.** *Secretary-Treasurer, William A. Klauber, M.D., Self Memorial Hospital, Greenwood. Meets with State Medical Association in May.*

**South Dakota**

**RADIOLOGICAL SOCIETY OF SOUTH DAKOTA.** *Secretary-Treasurer*, Donald J. Peik, M.D., 303 S. Minnesota Ave., Sioux Falls. Meets during annual meeting of State Medical Society.

**Tennessee**

**MEMPHIS ROENTGEN CLUB.** *Secretary*, Benjamin E. Greenberg, M.D., 294 Annella St., Memphis 11. Meets first Monday of each month at John Gaston Hospital.

**TENNESSEE RADILOGICAL SOCIETY.** *Secretary-Treasurer*, George K. Henshall, M.D., 311 Medical Arts Bldg., Chattanooga 3. Meets annually with State Medical Society in April.

**Texas**

**DALLAS-FORT WORTH RADILOGICAL CLUB.** *Secretary*, Albert H. Keene, M.D., 3707 Gaston Ave., Suite 116, Dallas. Meets monthly, third Monday, 6:30 P.M., at the Greater Fort Worth International Airport.

**HOUSTON RADILOGICAL SOCIETY.** *Secretary*, W. C. Owslay, M.D., 6409 Fannin, Houston 25. Meets fourth Monday at Texas Children's Hospital.

**SAN ANTONIO-MILITARY RADILOGICAL SOCIETY.** *Secretary*, Hugo F. Elmendorf, Jr., M.D., 730 Medical Arts Building, San Antonio 5, Texas. Meets at Brook Army Medical Center, the first Monday of each month.

**TEXAS RADILOGICAL SOCIETY.** *Secretary-Treasurer*, R. P. O'Bannon, M.D., 650 Fifth Ave., Fort Worth. Next meeting Jan. 20-21, 1956, Fort Worth.

**Utah**

**UTAH STATE RADILOGICAL SOCIETY.** *Secretary-Treasurer*, Angus K. Wilson, M.D., 343 S. Main St., Salt Lake City 1. Meets third Wednesday, January, March, May, September, November.

**Virginia**

**VIRGINIA RADILOGICAL SOCIETY.** *Secretary*, P. B. Parsons, M.D., 1308 Manteo St., Norfolk 7.

**Washington**

**WASHINGTON STATE RADILOGICAL SOCIETY.** *Secretary-Treasurer*, Eva L. Gilbertson, M.D., 1317 Marion St., Seattle 4. Meets fourth Monday, September through May, at 610 Pine St., Seattle.

**West Virginia**

**WEST VIRGINIA RADILOGICAL SOCIETY.** *Secretary*, W. Paul Elkin, 515-519, Medical Arts Bldg., Charleston. Meets concurrently with annual meeting of State Medical Society, and at other times as arranged by Program Committee.

**Wisconsin**

**MILWAUKEE ROENTGEN RAY SOCIETY.** *Secretary-Treasurer*, Jerome L. Marks, M.D., 161 W. Wisconsin Ave., Milwaukee 1. Meets monthly on fourth Monday at the University Club.

**SECTION ON RADIOLOGY, STATE MEDICAL SOCIETY OF WISCONSIN.** *Secretary*, Abraham Melamed, M.D., 425 E. Wisconsin Ave., Milwaukee 2. Meets in October with State Medical Society.

**UNIVERSITY OF WISCONSIN RADILOGICAL CONFERENCE.** Meets first and third Thursday at 4 P.M., September to May, Service Memorial Institute.

**WISCONSIN RADILOGICAL SOCIETY.** *Secretary-Treasurer*, W. W. Moir, M.D., Sheboygan Memorial Hospital, Sheboygan.

**Puerto Rico**

**ASOCIACIÓN PUERTORRIQUEÑA DE RADIOLÓGIA.** *Secretary*, Rafael A. Blanes, M.D., Box 9724 Santurce, Puerto Rico.

**CANADA**

**CANADIAN ASSOCIATION OF RADILOGISTS.** *Honorary Secretary-Treasurer*, D. L. McRae, M.D., *Assoc. Hon. Secretary-Treasurer*, Guillaume Gill, M.D., *Central Office*, 1555 Summerhill Ave., Montreal 25, Quebec. Meets in January and June.

**LA SOCIÉTÉ CANADIENNE-FRANÇAISE D'ÉLECTRO-RADIOLOGIE MÉDICALES.** *General Secretary*, Ls Ivan Vallée, M.D., Hôpital Saint-Luc, 1058 rue St-Denis, Montreal 18. Meets third Saturday of each month.

**L'ASSOCIATION DES RADILOGISTES DE LA PROVINCE DE QUÉBEC.** *ASSOCIATION OF RADILOGISTS OF THE PROVINCE OF QUEBEC.* *Secretary*, Jean-Louis Léger, M.D., 1560 Sherbrooke St. East, Montreal, P.Q. Meets four times a year.

**CUBA**

**SOCIEDAD DE RADIOLÓGIA Y FISIOTERAPIA DE CUBA.** *Secretary*, Dr. Rafael Gómez Zaldivar. Offices in Hospital Mercedes, Havana. Meets monthly.

**MEXICO**

**SOCIEDAD MEXICANA DE RADIOLÓGIA, A. C.** *Headquarters*, Calle del Oro, Num. 15, Mexico 7, D. F. *Secretary General*, Dr. Guillermo Santin. Meets first Monday of each month.

**PANAMA**

**SOCIEDAD RADIOLÓGICA PANAMEÑA.** *Secretary-Editor*, Luis Arrieta Sánchez, M.D. Apartado No. 86, Panama, R. de P.

## ABSTRACTS OF CURRENT LITERATURE

---

### ROENTGEN DIAGNOSIS

#### The Head and Neck

- WOOD, ERNEST H. Some Factors Which Affect the Value of Carotid Angiography in the Diagnosis of Brain Tumor.....  
 WEYAND, ROBERT D., AND CAMP, JOHN D. Roentgenographic Examination in Meningioma of the Tuberculum Sella or Olfactory Groove.....  
 PARSONS, THOMAS C., ET AL. Cerebral Angiography in Carotid Cavernous Communications.....  
 CARPENTER, MALCOLM B. Agenesis of the Corpus Callosum. A Study of 18 Cases Diagnosed During Life.....  
 STORM-MATHISEN, ARDIS. Traumatic Pneumocranial and Subdural Spinal Fluid.....  
 SEILS, H. A Contribution to the Picture of Diffuse Hyperostosis of the Skull (So-Called "Leontiasis Ossea").....  
 BROMBART, M., AND SCHUERMANS, J. New Products of Contrast for Roentgen Diagnosis in Otorhinolaryngology.....  
 SCHLOSSHAUER, B., AND MÖCKEL, G. Resorption of Contrast Material into the Blood Stream Following a Radiological Demonstration of the Maxillary Sinus.....

#### The Chest

- NORRIS, CHARLES M., AND STAUFFER, HERBERT M. Bronchography with Dionosil.....  
 MUNROE, W. G. C. Chest Roentgenographic Study of Employees in a Large Pharmaceutical Plant.....  
 JACOBSON, GEORGE, AND ADLER, DENIS C. Routine Admission Chest Roentgenographic Program at the Los Angeles County Hospital. A Report of the First Year.....  
 GOLDMAN, JOSEPH L., AND FREEMAN, JOSEPH. Carcinoma of the Bronchus with Negative X-Ray Findings.....  
 FORSTER, E., ET AL. Transversoaxial Tomography as a Valuable Help in Estimation of Operability of Pulmonary Cancer.....  
 NOEHREN, THEODORE H., AND MCKEE, FRANK W. Sarcoma of the Lung.....  
 COHEN, SAMUEL, AND ANG, ERIBERTO. Treatment of Pulmonary Tuberculosis with Isoniazide and Iproniazide.....  
 JACOB, G. Are There Typical X-Ray Findings of Interstitial Pneumonia in Premature Infants?.....  
 ACKERMAN, LAUREN V., ET AL. Localized Organizing Pneumonia: Its Resemblance to Carcinoma. A Review of Its Clinical, Roentgenographic and Pathologic Features.....

- GARAIX, J. P., AND ARNAUD, R. Dilatation of the Bronchi After Bronchial Trauma.....  
 KUNKEL, W. MINSTER, JR., ET AL. Mediastinal Granulomas.....

#### The Cardiovascular System

- 607 JACOBSON, GEORGE, ET AL. Cardiovascular Aspects of the Los Angeles County Mass Chest X-Ray Survey.....  
 607 BECKNER, GEORGE L., AND WINSOR, TRAVIS. Cardiovascular Adaptations to Prolonged Physical Effort.....  
 607 NERI, RAFAEL JOSÉ, ET AL. Pulmonary Circulation Time, Elbow-Left Ventricle and Elbow-Right Ventricle Circulation Times, Obtained by Means of Fluorodensitography with Radioopaque Substance.....  
 608 STEINBERG, ISRAEL, ET AL. Persistence of the Left Superior Vena Cava with Coarctation of the Aorta.....  
 608 KJELLBERG, SVEN R., AND OLSSON, STEN-ERIK. Roentgenologic Studies of the Sphincter Mechanism of the Caval and Pulmonary Veins.....  
 609 MCKUSICK, VICTOR A. Study of Mitral Regurgitation by Roentgen Kymography, with Observations on the Movement of Cardiac Calcifications.....  
 609 DIMOND, E. GREY, AND LIN, T. K. Clinical Picture of Pulmonary Stenosis. (Without Ventricular Septal Defect).....  
 609 MENON, A. N. K. Peripheral Angiography.....  
 610 EVSHOLDT, K.-G. A Contribution to Phlebography in Acute Circulatory Disturbances of the Lower Extremities.....  
 610  
 The Digestive System  
 610 WIRTS, C. WILMER, ET AL. Effect of Tea on Gastric Secretions and Motility.....  
 610 SUBBARAO, KAKARLA. Roentgenological Diagnosis of Alimentary Tract Emergencies in the New Born.....  
 610 PYGOTT, F. Fate of Bismuth Carbonate in the Stomach. A Radiological Study.....  
 610 IVIE, JOSEPH McK., AND BEVERIDGE, JOHN H. Roentgenologic Problems in Ulcers About the Pylorus.....  
 611 MADSEN, ERIK. Dysphagia in Bulbar and Pseudobulbar Lesions Simulating Oesophageal Carcinoma.....  
 611 SINGLETON, A. O., JR., AND ROWE, E. B. Peristalsis in Reversed Loops of Bowel.....  
 612 POLLOCK, LEO H. Tumors of the Small Intestine. MICHEL, MARSHALL L., JR., ET AL. Acute Obstructions of the Colon.....  
 612 HULTBORN, K. A. Causal Relationship Between Benign Epithelial Tumors and Adenocarcinoma of the Colon and Rectum.....

HOPFMANN, C. ROWELL. Teridax, A New Chole-		619	WICKBOM, INGMAR. Pyelography After Direct
cystographic Medium.....			Puncture of the Renal Pelvis.....
<b>The Diaphragm</b>			624
ORITT, JACOB E., AND HYDE, LEROV. Transdia-			CARR, REGINALD J. A New Theory on the For-
phragmatic Eventration of Peritoneum			mation of Renal Calculi.....
Secondary to Pneumoperitoneum.....		619	SMOOTHERS, W. J., AND SIEGEL, L. H. Rapid Iden-
			tification of Urinary Calculi Through Use of
			X-Ray Analysis.....
			625
HODGES, PAUL C. Normal Bone, Diseased Bone,			ELLIOT, JAMES S., AND ROSENBERG, MILTON L.
Dead Bone.....			Ureteral Occlusion by Barium Granuloma..
TURANO, ANDREW F., ET AL. Variations in Clin- ical Manifestations of Osteopetrosis. Two Cases.....		619	DANIEL, P. M., ET AL. Renal Circulation after
HARMS, I. Familial Acro-osteolysis.....			Temporary Occlusion of the Renal Artery..
PAUL, LESTER W. Punctate Epiphyseal Dyspla-			625
sia (Chondrodystrophia Calcificans Con- genita). Case with Nine Year Period of Ob- servation.....			<b>Miscellaneous</b>
ADAMS, WILLIAM C., AND HINDMAN, SARAH M.		619	DWORETZKY, MURRAY. Reversible Metastatic
Cat-Scratch Disease Associated with an			Calcification (Milk Drinker's Syndrome)...
Osteolytic Lesion.....		620	625
RESINK, J. E. J. A Case of Hemangio-Endo-			<b>Technic—Dosimetric Aspects</b>
thelioma of the Skeleton.....			SPIEGLER, G. The X-Ray Picture.....
COLEY, BRADLEY L., AND HIGINBOTHAM, NOR- MAN L. Secondary Chondrosarcoma.....		620	LAMY, R. Note on Horizontal Tomography....
LUDOVICO, NICOLA. Radiographic and Anatomic			626
Studies of the Parasternal Ossification			<b>RADIOTHERAPY</b>
Centers.....			620 STALLARD, H. B. Pathological Study of Retino-
BLOCH, HUBERT H. Case Report: Klippel-Feil			blastoma Treated by Radon Seeds and Ra-
Syndrome.....		620	dium Disks.....
GERSHON-COHEN, J., ET AL. Whiplash Fractures			626
of Cervicodorsal Spinous Processes.....			GARLAND, L. H., ET AL. Cancer of the Breast.
PALLIS, CHRISTOPHER, ET AL. Cervical Spon- dylosis. Incidence and Implications.....		621	Results of Radical Mastectomy and Radio- therapy in Two Hospitals.....
SCHORR, S., AND ADLER, E. Calcified Interverte- bral Disc in Children and Adults.....		621	627
HARRIS, W. ROBERT. Erosion of Bone Produced			KEEGAN, JAMES M., ET AL. Role of Irradiation
by Glomus Tumour.....		622	Therapy in the Treatment of Neuroblastoma
<b>The Spinal Cord</b>			627
CHAMBERS, WILLIAM R. Intrad spinal Tumor, A		622	DOUGLAS, R. GORDON, AND BIRNBAUM, STANLEY
Difficult Diagnosis.....			J. Urological Complications Following Radi- ological and Surgical Treatment of Carcinoma
<b>Gynecology and Obstetrics</b>			627
DALALI, SALIM J., ET AL. Application of Pelvic			O'BRIEN, FREDERICK W., AND O'BRIEN, FREDER-
Venography to Diagnostic Problems Associa- ted with Cancer of the Female Genital Tract			628
MAGNUSSON, WOLFGANG. On the Localization of			<b>RADIOISOTOPES</b>
Tubal Obstruction in Cases of Sterility from			
Different Causes.....		623	MORGAN, K. Z., AND FORD, M. R. Develop- ments in Internal Dose Determinations....
WALSH, JOHN W., ET AL. Isometric Pelvimetry..		623	629
GUNN, K. V. O. Analysis of Consecutive Radio- logical Pelvimetries on European Primiparae		623	BRUCER, MARSHALL. Standardized Co <sup>60</sup> Source
at the Queen Victoria Hospital, Johannesburg			Capsule for Teletherapy.....
<b>The Genitourinary System</b>			629
BURNS, EDGAR, AND HENDON, ROBERT G. Aortog- raphy as an Aid in the Management of Renal		623	FLOCKS, R. H., ET AL. Treatment of Carcinoma
Lesions.....			of the Prostate by Interstitial Radiation with
MILLER, GERALD M., ET AL. Renal Complica- tions from Aortography.....		624	Radioactive Gold (Au <sup>198</sup> ): A Follow-up Re- port.....
			629
			COOPER, JOHN A. D., ET AL. Intraprostatic In- jection of Radioactive Colloids. I. Distribu-
			tion and Excretion Following Injection in
			the Dog.....
			629
			BEADLES, ROBERT O., AND LEWIS, JAMES M.
			Radioactive Gold in Prostatic Cancer....
			630
			COWAN, IRVING I., ET AL. Transport of Radioac-
			tive Colloidal Gold Between Serous Cavities.
			630
			BAKAY, LOUIS. Studies on Blood-Brain Barrier
			with Radioactive Phosphorus. IV. Spatial
			Aspects of Phosphate Exchange Between
			Plasma and Brain. V. Effect of Cerebral
			Injuries and Infarction on the Barrier.....
			630
			EISENBERG, I. J., ET AL. Use of Radioactive
			Phosphorus in Detection of Intraocular Neo-
			plasmas.....
			631

- PHILLIPS, A. F. Gamma-Ray Dose in Carcinoma of the Thyroid Treated by Radio-Iodine.... 631  
 LOCKSLEY, HERBERT B., ET AL. Suitability of Tumor-Bearing Mice for Predicting Relative Usefulness of Isotopes in Brain Tumors. Comparative Clinical and Laboratory Study in Localization and Treatment of Brain Tumors with P<sup>32</sup>, Na<sup>24</sup>, K<sup>42</sup>, and Sodium Borate.....

#### RADIATION EFFECTS

- LENSON, NORMAN. Tricho-X-Ray Cancer. Another Case of Radiation-Induced Tumorigenesis.....  
 LANGE, ROBERT D., ET AL. Leukemia in Atomic Bomb Survivors. I. General Observations.  
 ARNOLD, ARTHUR, AND BAILEY, PERCIVAL. Alterations in the Glial Cells Following Irradiation of the Brain in Primates.....  
 ARNOLD, ARTHUR, ET AL. Effects of Betatron Radiations on the Brain of Primates.....  
 MARKS, JOSEPH H. Use of Chlorpromazine in Radiation Sickness and Nausea from Other Causes.....

#### RADIOBIOLOGY

- HICKS, SAMUEL P. Mechanism of Radiation Anencephaly, Anophthalmia, and Pituitary Anomalies.....

- SWIFT, M. N., ET AL. Regionally Fractionated X-Irradiation Equivalent in Dose to Total-Body Exposure..... 633  
 FULTON, GEORGE P., ET AL. Hematologic Findings in the Total Body X-Irradiated Hamster 634  
 FENTON, PAUL F., AND DICKSON, HARRISON M. Changes in Some Gastrointestinal Functions Following X-Irradiation..... 634  
 632 HAMMOND, CAROLYN W., ET AL. Studies on Susceptibility to Infection Following Ionizing Radiation. I. Time of Onset and Duration of the Endogenous Bacteremias in Mice.... 634  
 HAMMOND, CAROLYN W., ET AL. Studies on Susceptibility to Infection Following Ionizing Radiation. II. Its Estimation by Oral Inoculation at Different Times Post Irradiation..... 635  
 HALMI, N. S., AND GUDE, W. D. The Morphogenesis of Pituitary Tumors Induced by Radiothyroidectomy in the Mouse and the Effects of Their Transplantation on the Pituitary Body of the Host..... 635  
 DESAIVE, PAUL. Influences of the Mode of Irradiation, of Hypophysectomy, of Gonadotrophic Hormones, and of Chemical Radioprotective Substances on the Response of the Rabbit Ovary to X-Rays..... 635  
 STERNER, S. PHYLLIS, ET AL. Modification of the Radiation Syndrome in the Chick by Partial Body Shielding..... 635  
 NEWSON, B. D., AND KIMELDORF, D. J. Increased Tolerance to Hypoxia in Irradiated and in Food-Deprived Rats..... 636



## ROENTGEN DIAGNOSIS

### THE HEAD AND NECK

**Some Factors Which Affect the Value of Carotid Angiography in the Diagnosis of Brain Tumor.** Ernest H. Wood. Am. J. Roentgenol. 71: 952-957, June 1954.

In a series of 100 consecutive verified brain tumors, objective interpretation of cerebral angiograms led to a correct diagnosis in 81 instances. Accurate diagnoses by carotid angiography can be expected only with tumors in certain anatomical locations, *i.e.*, in the distribution of the larger carotid arterial branches. Suprasellar, frontal, and temporal tumors are most accurately diagnosed; parietal, occipital, and deep-seated tumors near the mid-line least so.

Carotid angiography appears to be most valuable for the confirmation of a clinical diagnosis of cerebral tumor rather than for demonstration of a clinically unlocalized tumor or as a screening procedure. In patients with sensory epilepsy, scintillating scotomas, involuntary movements, muscle rigidity and irritative disturbances of the parietal and occipital cortex, angiograms are not likely to demonstrate the lesion.

Plotting of the visual fields is helpful in predicting success or failure of angiographic diagnosis. Visual defects which denote a lesion at the optic chiasm suggest the presence of a process more amenable to diagnosis by carotid angiography than defects which indicate an abnormality of the optic radiations.

On the plain skull film, displacement of the pineal posteriorly, inferiorly, or laterally suggests an angiographically diagnosable tumor. Anterior or superior pineal displacement, or choroid plexus displacement, foretell failure of angiography.

Special reference is made to the anterior cerebral artery and its pericallosal branch, which, since it is inferior to the falk, can be displaced not only by frontal tumors but also by a tumor located anywhere in the displacing hemisphere if there is sufficient associated edema.

Eight roentgenograms; 2 drawings; 1 table.

LAWRENCE A. PILLA, M.D.  
University of Louisville

**Roentgenographic Examination in Meningioma of the Tuberculum Sella or Olfactory Groove.** Robert D. Weyand and John D. Camp. Am. J. Roentgenol. 71: 947-951, June 1954.

Camp, in 1931 (Proc. Staff Meet., Mayo Clinic 6: 221, 1931), listed five changes which may be seen in association with meningiomas arising in the region of the olfactory groove and tuberculum sellae, on routine roentgenography of the skull including lateral stereo views. These findings are: (1) formation of an osteoma at the point of origin of the tumor, (2) localized erosion of the cribriform plate of the ethmoid bone, the wing of the sphenoid bone, the sulcus chiasmatis and the tuberculum sellae, (3) erosion of the posterior clinoid processes, (4) enlargement and erosion of the sellae turcica, and (5) calcification within the tumor. In the present study, one or more of the above changes were observed in 33 or 51 cases of tuberculum sellae tumors and in 25 of 42 cases of olfactory groove tumor. Thus, careful study of well made roentgenograms of the skull should often suggest the diagnosis, though pneumoencephalog-

raphy, angiography, or even exploratory craniotomy may be required for its confirmation.

Four roentgenograms.

THOMAS E. PADGETT, M.D.  
University of Louisville

**Cerebral Angiography in Carotid Cavernous Communications.** Thomas C. Parsons, Emanuel J. Guller, Harold G. Wolff, and Howard S. Dunbar. Neurology 4: 65-68, January 1954.

A case of carotid-cavernous fistula in a 38-year-old schizophrenic woman is presented in which spontaneous occlusion followed angiography. About five weeks prior to the angiographic examination, the patient had two generalized grand mal type seizures. During the second she fell, striking the occiput. Following the injury she was stuporous, restless, and vomited freely; dark venous blood drained from the right ear. Findings on spinal puncture were normal. A roentgenogram of the skull disclosed no fracture. Headache developed and the left eye became proptosed and chemotic. A bruit was heard, maximal over the left eye but radiating to all portions of the ipsilateral skull as well as to the contralateral frontal region. A diagnosis of arteriovenous carotid cavernous fistula was made.

Left percutaneous angiography was unsuccessful, and therefore an open angiographic examination was performed under Pentothal anesthesia. This showed that the main venous drainage was through the superior and inferior ophthalmic veins, and thence *via* the facial veins into the general circulation. Failure to delineate the cerebral arterial channels, with alternative visualization of the cavernous sinus, ophthalmic, and facial veins during the usual "arterial phase," with the complete disappearance of the contrast medium from the cerebral circulation within approximately four seconds, was explained on the basis of a carotico-cavernous communication. Two hours after the angiographic examination, the patient became stuporous, the blood pressure dropped to 70/33, and the rectal temperature rose to 105°. Prompt therapy was instituted for shock, and three hours later consciousness was regained, the blood pressure rose to 90/60, and the temperature fell to 102°. The bruit over the left eye diminished and by the next day had entirely disappeared; the swelling and chemosis subsided within the succeeding four days. Re-examination of the left cerebral arterial circulation about four months later demonstrated the internal carotid artery and its division into the anterior cerebral artery and the middle cerebral artery. The branches of these two vessels were well visualized and showed no evidence of pathologic change. The arteriovenous aneurysm was no longer apparent, and there was no evidence of contrast medium within the venous circulation on the first arterial phase. The second and third films revealed the normal second arterial phase and the first venous phase. An anteroposterior view disclosed no pathologic changes.

It is suggested that the locally irritating and vasoconstrictor effect of the Diodrast utilized in the performance of the angiographic examination contributed toward thrombosis of the communication as evidenced by the normal vascular pattern obtained in the second angiogram.

Two roentgenograms.

**Agenesis of the Corpus Callosum. A Study of 18 Cases Diagnosed During Life.** Malcolm B. Carpenter. *Neurology* 4: 200-210, March 1954.

A study was made of 19 cases of agenesis of the corpus callosum, all but 1 of which were diagnosed during life. Only 3 of the cases have been reported previously (Davidoff and Dyke: *Am. J. Roentgenol.* 32: 1, 1934). Two cases came to necropsy and the clinical (roentgen) diagnosis was confirmed.

Nine of the patients of this series were females and 10 males. Initial symptoms became apparent prior to three years of age in 17 cases (in 6 immediately after birth). In the other 2, the first symptoms appeared at sixteen and twenty-three years. Jacksonian or focal seizures were the earliest manifestations in 7 patients; physical and mental retardation were given as the first symptoms in 6; progressive increase in head size was the first apparent abnormality in the remaining 6. Twelve patients (63 per cent of the entire group) had verified major seizures sometime during their illness; such seizures were focal or jacksonian in 9 cases. Twelve of the 15 patients studied by standard psychometric techniques were found to be mentally retarded or defective. Eight patients (42 per cent) were hydrocephalic.

Pneumoencephalographic studies were carried out in 12 patients, ventriculography in 4, and both pneumoencephalography and ventriculography in 3. In those cases subjected to both procedures, pneumoencephalography was usually done first and proved to be unsatisfactory. The five most common encephalographic features in order of frequency were: (1) dorsal extension and dilatation of the third ventricle, (2) wide separation of the lateral ventricles, (3) angular dorsal margins of the lateral ventricles (bat-wing appearance), (4) elongation of the interventricular foramina, and (5) dilatation of the posterior horns of the lateral ventricles.

Hyndman and Penfield (Arch. Neurol. & Psychiat. 37: 1251, 1937) and Pospeich (Ztschr. f. d. ges. Neurol. u. Psychiat. 174: 249, 1942) distinguished between complete and partial agenesis of the corpus callosum on the basis of encephalographic findings. Dorsal extension of the caudal portion of the third ventricle above the level of the lateral ventricles (in the lateral projection) was said to indicate partial agenesis, because the rudimentary or partially formed rostrum and body prevented dorsal displacement of the anterior part of the third ventricle. It is to be remembered that the corpus callosum develops in a rostrocaudal fashion, so that in partial agenesis of this structure it is usually the splenium and posterior portion of the corpus that are lacking or attenuated. When the rostral portion of the third ventricle is dorsally displaced between the lateral ventricles, the corpus callosum is usually completely absent. These encephalographic observations were confirmed by autopsy in 2 cases reported by Pospeich. On this basis it is felt that 18 of the author's cases represent complete agenesis of the corpus callosum. In 1 case the third ventricle was not adequately visualized, making it impossible to judge whether agenesis was complete or partial. A notching of the third ventricle in 1 case was thought to have been produced by the falx cerebri. Although porencephalic cysts are a not uncommon associated finding in agenesis of the corpus callosum, only one such cyst was found.

It is postulated that the high incidence of focal or jacksonian seizures in patients with agenesis of the corpus callosum may be due to deficient neopallial com-

missural fiber systems which inhibit the spread of the seizure to the opposite hemisphere.

Fifteen roentgenograms; 3 tables.

**Traumatic Pneumocranial and Subdural Spinal Fluid.** Ardis Storm-Mathisen. *Neurology* 4: 78-82, January 1954.

A case of traumatic pneumocranial with subdural spinal fluid is reported. The patient was a 55-year-old dockworker who had fallen headlong off a wharf, with compression of the head between the wharf and the side of a freighter. There was loss of consciousness for about two hours, with anterograde and retrograde amnesia. Routine x-ray examination of the skull two hours after the accident disclosed several fractures. The most striking finding, however, was air in the ventricles of the brain, together with subarachnoid and subdural air. The subdural air was distinctly present three days after the accident, but had disappeared by the tenth day. The intraventricular air was still present at ten days, though substantially reduced in quantity; nineteen days after the accident it, too, had disappeared.

There are two forms of pneumocranial associated with fracture of the skull, depending on whether the dura only or the dura and the arachnoid are severed. In the first type, air may pass into the potential subdural space between the dura and the arachnoid. Radiographically a continuous air-mantle is seen at the highest level of the cranial cavity. The brain and arachnoid drop away from the dura, and the contour of the brain may be observed in the lower part of the air-mantle. The present case is of the second type, with intraventricular and subarachnoid air and a distinct mantle of subdural air from which the brain rises, calotte-shaped, through a horizontal level of spinal fluid.

The neurologic findings in the present case were bilateral lesions of the sixth, seventh, and eighth cranial nerves, resulting in difficulties in eating and speaking. The usual post-traumatic complaints, such as headache and dizziness, were not present.

Three roentgenograms; 2 photographs.

**A Contribution to the Picture of Diffuse Hyperostosis of the Skull (So-Called "Leontiasis Ossea").** H. Seils. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 80: 738-742, June 1954. (In German)

The term "leontiasis ossea," as first used by Virchow in 1864, was meant to apply to any abnormal enlargement and thickening of the head and face. Later, this designation was rejected by many authors because it was felt that an enlarged head was a symptom associated with a variety of disturbances, such as osteitis deformans (Paget's disease), osteitis fibrosa generalisata (von Recklinghausen's disease), fibrous dysplasia, marble bones, etc.

The author describes the case of a fifty-three-year-old man who had had an abnormally large head and face since childhood. His brother, father, and grandmother were similarly afflicted. X-ray films showed marked thickening of the cranium and considerable enlargement of the lower jaw. The rest of the skeleton was normal, as were the blood count and blood chemistry. The neurologic examination showed only some impairment of the hearing, due to disease of the inner ear.

In discussing the differential diagnosis in this case, the author rules out von Recklinghausen's disease on account of the normal blood chemistry, Paget's disease on account of the childhood history (Paget's disease

ordinarily does not occur in childhood), and fibrous dysplasia on account of the hereditary factor. He is inclined to consider this case as a monosymptomatic form of marble bones. He does not believe that there is an idiopathic form of diffuse hyperostosis of the skull and feels that the term "leontiasis ossea" should be discarded.

Two roentgenograms; 2 photographs.

WILLIAM A. MARSHALL, M.D.  
Chicago, Ill.

**New Products of Contrast for Roentgen Diagnosis in Otorhinolaryngology.** M. Brombart and J. Schuemans. *J. belge de radiol.* 37: 481-489, 1954. (In French)

Some of the new contrast agents employed in bronchography have shown optimum viscosity for coating mucosal surfaces. Of these, the authors have used Lipiodol mixed with sulfanilamide powder, talc, or calcinated magnesium, as well as aqueous and oily forms of Dionosil, for demonstration of the paranasal sinuses, hypopharynx, and laryngeal region. Oily Dionosil was found to be especially useful as a diagnostic contrast agent to produce mucosal coating in these structures.

Twelve roentgenograms.

CHARLES M. NICE, JR., M.D.  
University of Minnesota

**The Resorption of Contrast Material into the Blood Stream Following a Radiological Demonstration of the Maxillary Sinus.** B. Schlosshauer and G. Möckel. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 80: 708-713, June 1954. (In German)

It is well known that the use of contrast material may produce serious and even lethal reactions. The authors sought to evaluate the dangers of introduction of a contrast medium into the maxillary sinuses. The material most commonly used for this purpose is a pyridone-iodine compound, as Perabrodil, Uroslectan B, Xumbradil, etc.

A careful blood analysis to determine the iodine content was made on 21 patients in whom the maxillary sinus had been demonstrated with 5 c.c. of a 60 per cent viscous aqueous solution of Perabrodil. Blood specimens were taken before the examination and at various intervals from two minutes to five hours after instillation of the medium.

It was found that the blood level of iodine was quite low in the presence of a normal mucous membrane, 0.2 mg. per cent. It was increased in the presence of inflammatory mucosal changes or polypi to as much as 1.4 mg. per cent, and also in the presence of renal damage producing a delay in the excretion of the medium. The resorption of the compound gradually increases, reaches a maximum in two to four hours after injection, and then slowly declines as the iodine is eliminated through the kidneys.

The low blood levels of iodine in this study are in contrast to those in intravenous pyelography, in which the level may reach 200 mg. per cent; to retrograde pyelography, with a maximum of 23.9 mg. per cent; and bronchography, 29 mg. per cent. In retrograde pyelography and in the demonstration of the maxillary sinus, the conditions appear to be somewhat similar anatomically, inasmuch as a closed small body cavity is filled.

The authors believe, however, that in retrograde pyelography the kidney pelvis over-expands under the increased pressure and that a certain amount of contrast medium, escaping through small tears, may suddenly flood the circulation. In the maxillary sinus this is not possible; the rigid bony structures prevent over-expansion of the sinus and excess medium runs out through the maxillary foramen.

Of the various tests for sensitivity, the skin tests and the cornea tests may be misleading, because the quantity of material used is small. It is believed that in the average patient a larger amount is needed to produce a noticeable reaction and that the threshold in patients varies widely. A more or less reliable test is the intravenous injection of 1.0 c.c. of a 35 per cent solution of Perabrodil, but this produces a blood level of 6 to 10 mg. per cent of pyridone-iodine, which is many times in excess of the maximal blood level seen following the usual contrast visualization of the sinuses. For this reason, it is believed that a sensitivity test is unnecessary in visualization of the sinuses. In 116 sinus examinations the authors have never seen any serious allergic reaction. Urticaria developed in only one patient. More important than the usual test is a history to indicate whether serious allergies exist; if so, an intracutaneous test with isotonic contrast material may be done. However, not even this is wholly reliable.

One roentgenogram; 2 graphs.

WILLIAM A. MARSHALL, M.D.  
Chicago, Ill.

## THE CHEST

**Bronchography with Dionosil.** Charles M. Norris and Herbert M. Stauffer. *Ann. Otol., Rhin. & Laryng.* 63: 520-531, June 1954.

Dionosil is an iodine preparation similar in chemical composition to Diodrast. It is available in aqueous or oily suspension. The aqueous preparation makes use of sodium carboxymethyl cellulose to provide viscosity; for the oily suspension arachis oil is used as the vehicle. The iodine content is about 30 and 34 per cent respectively. The size of the suspended particles is in the range of 5 to 15 micra. The medium may be instilled by any of the conventional methods but the authors prefer the catheter technic of intrabronchial instillation.

Aqueous Dionosil is isotonic and less irritating than aqueous media heretofore available. Although it is less viscous than iodized oil, it produces less alveolar filling, so that the instillation and incidental fluoroscopic observation need not be hurried. Uniform coating of the bronchial mucosa is obtained, and excellent demonstration of the smaller peripheral bronchi may be achieved with consistency. Within four days the medium is usually eliminated, leaving no residual opacities. Dionosil Oily is similar to the aqueous preparation in its behavior except that it requires slightly less topical anesthesia, has a greater tendency to alveolar filling, and requires two or three days longer for elimination.

In a series of bronchographic studies, 87 with aqueous and 45 with oily Dionosil, there were only 3 instances of sequelae other than transient temperature elevation: 2 patients complained of chest pain and 1 had a transient pneumonitis.

[The 5 roentgenograms accompanying this report speak well for the new medium.—D.D.R.]

D. D. ROSENFIELD, M.D.  
Oakland, Calif.

**Chest Roentgenographic Study of Employees in a Large Pharmaceutical Plant.** W. G. C. Munroe. *Arch. Indus. Hyg. & Occup. Med.* 9: 361-365, May 1954.

A survey was made of 20,823 chest roentgenograms taken during a five-and-one-half year period at a large pharmaceutical plant (Lederle Laboratories, Pearl River, N. Y.). The number of employees examined ranged from 2,088 in 1948 to 4,393 in 1943, with a total of 18,625 annual examinations, exclusive of temporary building contractors and their employees.

An effort is made to examine each employee at yearly intervals or oftener; this examination includes a 14 X 17-inch roentgenogram, a physical examination, and certain laboratory studies, such as electrocardiography on all over forty years of age. For every applicant for employment a pre-employment chest roentgenogram is obtained and must be adjudged safe for employee and employer before his acceptance.

In the present survey, cardiac hypertrophy was found in 60 cases, in 45 apparently due to hypertension. In 12 cases it was thought to be caused by proved cardiac disease of other etiology. The aortic knob was enlarged or calcific in 26 persons without cardiac hypertrophy but with clinical hypertension in 20. In 29 of those with cardiac enlargement, the aortic knob was prominent or contained calcium; 26 of these persons had hypertension. The pulmonary conus was prominent in 4 persons, 2 of whom had clinical evidence of pulmonary stenosis.

Abnormalities of the diaphragm proved to be due chiefly to herniations and numbered 10, 5 being demonstrated by fluoroscopy and barium meal.

Rib fractures numbered 26 and fractures of the clavicle 2. There were deformities of ribs due to resectional surgery in 6 persons, marked scoliosis of the spine in 12, and spinal arthritis in 3, including a case of Marie-Strümpell disease.

Notable mediastinal abnormalities were not frequent. Three persons had bilateral enlargement of mediastinal nodes, the cause for which was never found. Bronchoscopy, Mantoux tests, and gastric lavages were negative in these, and the enlargement receded within six months. There was one case of neurofibroma, 2 of substernal thyroid, 2 of Boeck's sarcoid, 1 of Hodgkin's disease, and 1 of carcinoma of the left hilar nodes.

Nine persons with active tuberculosis were rejected on application for employment, and 3 more were found to have had relapses while working. Fifteen others were studied until satisfactory evidence of inactivity of pulmonary lesions was provided before employment. A total of 79 persons were classified as having active, inactive or suspected pulmonary or pleural tuberculosis. Pneumonia, chiefly bronchopneumonia, was the next most common finding. Emphysematous changes were observed rather frequently, especially in persons over forty. Peribronchial pulmonary lesions associated with asthma, silicotic changes, bronchiectasis, and Boeck's sarcoid were found infrequently. Pulmonary carcinoma was discovered in only 2 persons and in 1 the tumor was metastatic.

Three tables.

**The Routine Admission Chest Roentgenographic Program at the Los Angeles County Hospital. A Report of the First Year.** George Jacobson and Denis C. Adler. *Am. Rev. Tuberc.* 69: 940-956, June 1954.

The value of routine chest roentgenograms on patients

admitted to general hospitals has long been recognized. The Los Angeles County Hospital used 70-mm. roll film with photofluorographic units for examination in either the upright or supine position. A twenty-four-hour service was maintained, and films were delivered to the ward about twenty-four hours after the patient had been admitted. In the period from Nov. 1, 1951, through Oct. 31, 1952, a total of 77,789 patients were available for examination and 63.6 per cent of these had admission photofluorograms, more than one-half of which were done in the supine position. After special stretchers were used which permitted radiography without moving the patient, the percentage of films obtained was increased to 81.5 per cent.

A diagnosis (proved) of tuberculosis was made in 719 patients; the disease had not been previously suspected in 457 of these. Active tuberculosis was found in 349 cases, of which 208 were previously unknown. Approximately one-half of the tuberculosis was found in white males more than forty years old.

Two roentgenograms; 1 photograph; 2 charts; 6 tables; 3 graphs.

JOHN H. JUHL, M.D.  
Minneapolis, Minn.

**Carcinoma of the Bronchus with Negative X-Ray Findings.** Joseph L. Goldman and Joseph Freeman. *Ann. Otol., Rhin. & Laryng.* 63: 500-508, June 1954.

The authors report 3 cases of bronchogenic carcinoma, diagnosed by bronchoscopy, in which routine chest roentgenograms were reported negative. In each instance the patient complained of cough and hemoptysis and at bronchoscopy a tumor was identified in one of the main bronchi. Pneumonectomy was done on all three cases. No patient survived beyond eighteen months.

In spite of the increased use of chest roentgenograms, the five-year cure rate for all lung cancer remains low—approximately 5 per cent. The authors feel that the main reason for this low rate is that the lesion usually has extended beyond the lung by the time operation is performed. Since the majority of bronchial carcinomas are located in the bronchi of the first three orders, more emphasis on early bronchoscopy in patients showing signs of bronchial irritation will offer greater opportunity for early diagnosis. This does not minimize the importance of careful x-ray study which includes lateral, oblique, inspiratory, and expiratory films. The authors feel, however, that for cancers of the main bronchi, endoscopic observation is the most direct method, short of thoracotomy, of establishing a diagnosis, and that it "offers greater possibilities of detecting the early lesion than even the most careful x-ray studies."

D. D. ROSENFELD, M.D.  
Oakland, Calif.

**Transversoaxial Tomography as a Valuable Help in Estimation of Operability of Pulmonary Cancer.** E. Forster, D. Sichel, and E. Roegel. *J. Thoracic Surg.* 27: 593-604, June 1954.

The authors have used transverse axial tomography as a means of determining the operability of cancer of the lung. Anteroposterior and lateral films of the chest afford a gross view of the tumor; frontal tomography helps to determine the size and shape of the mass and to indicate involvement of the main or secondary bronchi; lateral tomograms aid in localization of the lesion. None of these studies, however, furnishes reliable in-

formation concerning extension into the mediastinum. This is supplied by transverse axial tomography. With this procedure, it is possible to determine whether a cleavage plane exists between the tumor and the mediastinal organs, thus indicating operability or inoperability. Three cases with appropriate reproductions of routine and transverse tomograms illustrate this advantage.

It is pointed out, however, that the value of the procedure is limited by the anatomic disposition of the intrathoracic structures. The rather straight line of the right side of the heart and great vessels makes the findings on the right side more accurate than on the left, where the horizontal component of the heart and aortic arch may blend with the tumor and make determination of a plane of cleavage difficult. Three further cases are presented to illustrate this point.

The authors tried to bring out superimposed shadows in the mediastinum by means of pneumomediastinum. This, however, has not proved satisfactory.

Fifteen roentgenograms; 7 diagrams.

RENE G. FORTIER, M.D.  
St. Paul, Minn.

**Sarcoma of the Lung.** Theodore H. Noehren and Frank W. McKee. *Dis. of Chest* 25: 663-678, June 1954.

The authors have assembled from the medical literature since 1912 a group of 34 cases of sarcoma of the lung, to which they add a thirty-fifth. The patient was a 60-year-old white woman, who complained of shortness of breath, a dry, non-productive cough for four years, and one transient episode of ankle edema five days prior to admission. She had had no precordial or chest pain. The left lung was clear to auscultation and percussion. The right chest, however, was flat to percussion, with absence of breath sounds, tactile fremitus, and whispered voice below the mid-scapular region posteriorly and over the lower right axilla.

Shortly after hospital admission, 850 c.c., and two days later 950 c.c., of cloudy yellow fluid was removed from the right chest by thoracentesis. This contained many lymphocytes and round cells with dark-staining nuclei, but no definite diagnosis was made. The patient became steadily weaker and more dyspneic and died twenty-five days after admission.

At necropsy, large firm nodules of grayish-yellow tumor tissue were found in the base of the lower lobe of the right lung, the largest measuring about 5 cm. in diameter. There were numerous other smaller nodules of similar tissue, with grayish streaking along the bronchi suggestive of lymphatic involvement. On microscopic examination, the tumor cells appeared to be of connective-tissue origin, some resembling adult fibroblasts. Others were younger, more oval, and with processes.

The observations in this case are assembled with those for the 34 previously reported cases and a composite picture of sarcoma of the lung is obtained. There was no uniformity in the roentgen appearance of the pulmonary sarcomas in this series, and there was nothing to distinguish them from other types of lung tumor. In one case the sarcoma contained calcium, while several others had degenerated into necrotic abscesses. In the authors' case effusion was the major roentgen finding.

Of the total 35 cases, 17 (48.5 per cent) were amenable to surgical procedures of one sort or another. Follow-up for various periods [none as long as five years] showed

59 per cent of the patients who survived operation still alive.

One roentgenogram; 1 photomicrograph; 3 charts.

G. M. RILEY, M.D.  
Shreveport, La.

**Treatment of Pulmonary Tuberculosis with Isoniazide and Iproniazide.** Samuel Cohen and Eriberto Ang. *Dis. of Chest* 25: 622-639, June 1954.

The authors report their observations on 76 patients with pulmonary tuberculosis treated with Isoniazide and Iproniazide. The series included: (1) patients with active pulmonary tuberculosis who had received chemotherapy and bed rest but who were still febrile, with stationary or progressive lesions; (2) patients with acute bronchopneumonic exudative pulmonary tuberculosis; (3) an intermediate group with active pulmonary disease and positive sputum who had not shown significant improvement over a reasonable period of time and to whom standard antibiotics may or may not have been administered; (4) an elective group of cases with bronchopleural or pleural-cutaneous fistulae, usually secondary to thoracic surgery.

Fifty-nine patients, constituting the authors' Group I, received Isoniazide for ninety days, in increasing doses. Thirty-four of these had at one time been treated with Streptomycin, alone or in combination with PAS. At the conclusion of the ninety days, 39 cases were available for further observation, and these were regrouped as follows. Group II, made up of 22 patients who showed improvement roentgenologically, was continued on Isoniazide for another ninety days. Group III, numbering 6 patients who had never received Streptomycin and who showed no roentgen improvement, was given further treatment with Isoniazide along with Streptomycin for ninety days. Group IV, 11 patients who had previously been given Streptomycin but, like those of Group III, had shown no roentgen improvement on Isoniazide, was continued on the drug for ninety days. A further group, Group V, not included in Group I, received Iproniazide. There were 17 cases in this group.

Iproniazide was found to be superior to Isoniazide in producing a more prompt reduction in febrile toxicity and in accelerating gain in weight. There was no significant difference, however, in the regressive x-ray film changes noted with the ninety days of Isoniazide therapy in Group I (52 per cent) as compared to Group V receiving Iproniazide, (50 per cent). Of the 39 cases followed in Groups II, III, and IV, a total of 19 (approximately 50 per cent) showed further improvement roentgenologically. The course of 180 days of Isoniazide alone appeared superior in this respect to the other regimens. However, in the group receiving Streptomycin plus Isoniazide there was not a single instance of progression of the lesion. The most favorable therapeutic effect was observed in the resolution (of varying degree) of the exudative component of the parenchymal process. While reduction in size of cavitation was seen in a number of instances, in only 1 was it impossible to demonstrate residual cavitation on laminagraphy. After ninety days of therapy, the incidence of sputum conversion was three times higher with Isoniazide (36 per cent) than with Iproniazide (12 per cent). After 180 days of treatment in Groups II, III, and IV, the conversion rate dropped considerably, averaging about 16 per cent.

There was a relatively high incidence of toxic reac-

tions to both drugs. These were more frequent (61 per cent) with Iproniazide and tended to be more severe and progressive. For this reason, the latter drug is not at present advocated for the average case of pulmonary tuberculosis.

The number of bacterial sensitivity examinations made in this study were inadequate for any conclusions, but bacterial resistance appears to be a limiting factor.

Five tables.

G. M. RILEY, M.D.  
Shreveport, La.

**Are There Typical X-Ray Findings of Interstitial Pneumonia in Premature Infants?** G. Jacob. Fortschr. a. d. Geb. d. Röntgenstrahlen 80: 697-708, June 1954. (In German)

It is now generally recognized that the interstitial pneumonia of premature children represents a well defined clinical entity, though its etiology is still poorly understood. As far as the pathology is concerned, the disease goes through three stages: edema, atelectasis, and emphysema. All lobes of the lungs are usually involved, but the three phases do not necessarily occur in all lobes at the same time. There is thus an overlapping of manifestations which sometimes gives the lungs a varied appearance. Microscopically the large bronchi show no involvement. The smaller bronchi are infiltrated by lymphocytes and plasma cells.

The edema of the early stage gradually extends over into the alveoli, occludes the bronchioli, and produces an atelectasis. Later the atelectatic areas begin to shrink, causing emphysema in the adjoining sections. The emphysema is chiefly of the bullous type and may lead to the formation of large blebs. The atelectasis involves relatively small, widely separated areas, producing a spotty appearance on the x-ray films, which becomes more manifest as the emphysema around the spots increases.

The author has carefully studied the histories and the x-ray films of 72 clinically and (in most cases) histologically proved cases of interstitial pneumonia of premature infants and has reached certain radiological conclusions. In most cases there is involvement of both lungs (93 per cent), but the lesion is usually more intense on the right side than on the left. Lesions of the upper and mid-portions of the lungs predominate; the bases are seldom involved. The radiological appearance will vary with the pathological phase that exists at the time. In the phase of edema, the shadows will be homogeneous, ranging from a light, veil-like density to deep opacities. As the large bronchi are not affected, the second phase of the disease (atelectasis) does not involve one large section of the lung. The atelectases become manifest on the films as small spots ranging in size from a pinpoint to a small pea. As the third stage (interstitial emphysema) develops, the lung tissue surrounding these atelectatic foci becomes lighter, making the spots more distinct. Sometimes the atelectatic foci become confluent and produce streaks. The emphysema is particularly noticeable in the lower and lateral portions of the lungs. For the most part, the pleura is not involved. The diaphragm is usually low. Emphysema of the mediastinum is occasionally observed and is prognostically an unfavorable sign. Pneumothorax occurs in about 5 per cent of the cases, but on account of the edema of the lungs, it usually involves only a small, narrow, lateral portion of the thoracic cavity. The heart shadow is often smaller than normal, which may be due to compression in con-

nexion with the emphysema. The lung roots are not much affected and the hilar shadows therefore show little change.

Ten roentgenograms; 2 tables.

WILLIAM A. MARSHALL, M.D.  
Chicago, Ill.

**Localized Organizing Pneumonia: Its Resemblance to Carcinoma. A Review of Its Clinical, Roentgenographic and Pathologic Features.** Lauren V. Ackerman, Gladden V. Elliott, and Mario Alanis. Am. J. Roentgenol. 71: 988-996, June 1954.

The authors report 15 cases of which 10 were diagnosed both clinically and roentgenographically as carcinoma of the lung but on thoracotomy were found to be organizing pneumonia. To aid the radiologist in making a differentiation, laminagraphy is suggested. Laminographic findings which would tend to rule out carcinoma include absence of bronchial occlusion and the presence of calcification within a hilar mass. Also favoring an inflammatory origin is extension of infiltration to a pleural surface, with formation of a loculated empyema.

The findings at operation in most of the cases in this series were interpreted by the surgeon as indicative of carcinoma. The pleura was thickened in all instances, and in a few fibrous tissue had extended into the chest wall. Only on examination of frozen sections was the correct diagnosis made in 10 cases. In an eleventh case the frozen section was misinterpreted due to inexperience on the part of the pathologist.

The authors point out that frozen section is invariably diagnostic of organizing pneumonia and stress its importance. With this diagnosis, lobectomy can be done rather than pneumonectomy, thus conserving pulmonary parenchyma, which may be an important consideration in the older patient.

Twelve roentgenograms; 3 photomicrographs; 1 photograph.

THOMAS E. PADGETT, M.D.  
University of Louisville

**Dilatation of the Bronchi After Bronchial Trauma\*** J. P. Garrix and R. Arnaud. J. franç. de méd. et chir. thorac. 8: 418-422, 1954. (In French)

Twenty cases of traumatic bronchial stenosis have been reported in recent years. Traumatic bronchial rupture often ends in death.

A case is reported in a 24-year old married woman who had, without prodromes, a moderate hemoptysis in the middle of the night. The history revealed that the patient had fallen violently down a stairway at the age of ten years. At that time she lost consciousness and suffered shock and abundant hemoptysis. The accident occurred in the country and only after several weeks was a radiograph taken, which demonstrated pleural fluid on the left. On the present admission, routine radiographic and tomographic studies revealed retraction of the trachea to the left and elevation of the left hemidiaphragm. Bronchography revealed bronchiectasis of the contracted left lung distal to stenosis of the left main bronchus. The anterior segment of the right upper lobe and the right middle lobe had herniated across the mediastinum to occupy part of the left hemithorax.

Four roentgenograms.

CHARLES M. NICE, JR., M.D.  
University of Minnesota

**Mediastinal Granulomas.** W. Minster Kunkel, Jr., O. Theron Clagett, and John R. McDonald. *J. Thoracic Surg.* 27: 565-574, June 1954.

The authors report 16 cases of mediastinal granuloma in which a thoracotomy was performed. They found 16 previously reported cases similarly proved. In the present series the average age was thirty-two; the division between the sexes was equal.

The majority of mediastinal granulomas are cystic, arising from lymph nodes, usually in the paratracheal region. In the past, most of these lesions were thought to be tuberculomas, but actually in most cases the etiology cannot be determined. For that reason the authors prefer the term "mediastinal granulomas."

Thirteen of the authors' cases presented minimal symptoms, or none at all, and were discovered on routine roentgenograms. One patient had pleuritic pain, fever, and weight loss; another complained of dyspnea, substernal heaviness, and a low-grade fever; a third had a wheezing cough and fever.

The radiologic appearance in 13 of the cases was that of a paratracheal mass on the right. In 1 case the mass projected from both sides of the trachea; in 1 it occupied the left hilus, and in the remaining case was in the left postero-inferior part of the mediastinum, displacing the esophagus to the left and anteriorly. The lesions were well circumscribed, with an oval or smoothly lobulated contour. Often, there was partial calcification in the periphery. Some showed central stippled calcification.

Eleven of the granulomas were cystic with a soft necrotic center; 2 had the appearance of granulomatous lymph nodes without caseation; 3 were solid, with areas of cystic degeneration.

No organisms were demonstrated by cultural or inoculation studies. In one patient, a child of two years, a presumptive diagnosis of primary tuberculosis was made, and the child was positive to first-strength P.P.D. In none of the other cases was any etiologic relationship established by laboratory methods.

Most mediastinal granulomas probably proceed to a benign resolution through fibrosis or calcification. The authors speculate as to whether rupture of the cystic lesion may not produce a constricting mediastinitis, or whether fibrosis in an unruptured lesion might not cause superior vena caval obstruction. In 3 of their cases progressive enlargement of the mass was observed, and at operation spontaneous rupture appeared to be imminent in several instances. Such eventualities probably make excision advisable.

Seven roentgenograms; 6 photographs; 2 photomicrographs.

RENE G. FORTIER, M.D.  
St. Paul, Minn.

#### THE CARDIOVASCULAR SYSTEM

**The Cardiovascular Aspects of the Los Angeles County Mass Chest X-Ray Survey.** George Jacobson, Maurice L. Lipkis, and Catherine Hull. *Am. Heart J.* 47: 860-873, June 1954.

While the mass chest x-ray survey is a valuable case-finding method for tuberculosis, there is a divergence of opinion as to its usefulness in the detection of cardiovascular disease. In a survey conducted in Los Angeles County during 1950, 1,736,703 persons were satisfactorily examined on 70-mm. film. In 10,899 (6.3 per 1,000) the findings were suspicious of cardiovascular disease, and in 8,532 of these (78.3 per cent) re-examination,

also on 70-mm. film, was done. This second set of films was reviewed by a radiologist and cardiologist: 1,853 (21.7 per cent) were declared essentially negative, while abnormal findings significant for follow-up were present in 6,551 (76.8 per cent). Criteria determining abnormality were those established by the U. S. Public Health Service, based upon (1) cardiac size, (2) contour, and (3) changes in the great vessels. No attempt was made to postulate an etiologic diagnosis.

Of the 6,551 persons with abnormal findings 6,226 had cardiovascular disease only; in 46 there was associated tuberculosis, in 56 neoplasm, and in 223 other chest diseases.

All those with cardiac abnormalities were referred for medical follow-up. Final reports were received on 4,456. In 3,388 the diagnosis of heart disease was confirmed.

A total of 697 cases of previously unknown cardiovascular disease was disclosed by the survey. The survey also led 710 patients with previously known cardiovascular disease to return to medical care. Thus, while the mass survey is not the best cardiac case-finding method, the recognition of cardiovascular disease is an integral part of any such chest survey.

Three graphs; 19 tables.

HENRY K. TAYLOR, M.D.  
New York, N. Y.

**Cardiovascular Adaptations to Prolonged Physical Effort.** George L. Beckner and Travis Winsor. *Circulation* 9: 835-846, June 1954.

Electrocardiographic, radiographic, and other observations are reported for 165 marathon runners with five years of physical training. The findings before and after running as much as 26 miles were compared with those of a control group of 40 non-runners of about the same age and size.

A characteristic electrocardiographic picture was found in the runners, consisting of a slow cardiac rate with high voltage of QRS complexes, T and U waves, findings which are observed with right and left ventricular enlargement without evidence of cardiac disease.

Teleradiographs of the hearts of the runners at rest showed the presence of cardiac enlargement in a significant percentage of subjects. Both the long and broad diameters of the heart were increased above normal. In general the x-ray films revealed a cardiac silhouette which was long and extended to the left. The pulmonary artery and pulmonary vascular markings were considerably increased in diameter and density. The great vessel shadows were large. After running, a reduction in the cardiac shadow was observed.

These findings are significant in relation to the differential diagnosis of cardiac enlargement.

Three roentgenograms; 8 electrocardiograms; 1 graph; 9 tables.

ZAC F. ENDRESS, M.D.  
Pontiac, Mich.

**Pulmonary Circulation Time, Elbow-Left Ventricle and Elbow-Right Ventricle Circulation Times, Obtained by Means of Fluorodensigraphy with Radioactive Substance.** Rafael José Neri, Guillermo Villagorda, Gustavo Moros, and Narno Dorbecker. *Am. Heart J.* 47: 818-823, June 1954.

Ventricular volume curves depend upon density changes produced by emptying and filling of the cham-

bers in each cardiac cycle. The introduction of contrast substance into the blood stream increases the amplitude of the wave forms. It is upon this latter fact that the authors have based the procedure which they call "fluorodensography" (see Moros *et al.*: Am. Heart J. 45: 495, 1953. Abst. in Radiology 62: 448, 1954). The present paper describes the use of the method to determine the time required for contrast substance to reach the right and left ventricles from the right elbow. Subtracting right-elbow-to-right-ventricle time from a right-elbow-to-left-ventricle time gives the pulmonary circulation time. Four cubic centimeters of 70 per cent Diodrast was injected and the beginning and the end of the injection were indicated on the electrokymographic tracing. The elapsed time from the point coincident with the middle of the distance between the beginning and end of the injection to the first recorded change on the tracing was measured as the time factor.

In 19 normal subjects between the ages of seventeen and forty-four it was found that the average elbow-to-right-ventricle time was 1.63 seconds  $\pm 0.23$ , while the elbow-to-left-ventricle time was 5.61 seconds  $\pm 0.59$ . The pulmonary circulation time was 3.98 seconds  $\pm 0.61$ . The number of cardiac cycles with graphic changes averaged 1.68 for the right ventricle and 5.16 for the left ventricle.

A twelve-year-old normal boy was also studied, and the findings were quite close to those for the adults: 1.64 seconds, elbow-right-ventricle time; 5.52 seconds, elbow-left-ventricle time; 3.88 seconds, pulmonary circulation time. Also studied was a seventy-five-year-old male with a pulmonary artery aneurysm. In this case the arm-to-right-ventricle time was 4.2 seconds; to left ventricle, 41.0 seconds; pulmonary circulation time, 36.8 seconds.

Two illustrations; 1 table.

HENRY K. TAYLOR, M.D.  
New York, N. Y.

**Persistence of the Left Superior Vena Cava with Coarctation of the Aorta.** Israel Steinberg, Charles S. Harrison, and Ward D. O'Sullivan. J. Thoracic Surg. 27: 575-580, June 1954.

The authors present the fifth reported case of coarctation of the aorta associated with persistence of the left superior vena cava, and the first to be diagnosed during life. The coarctation was about 1.5 cm. beyond the origin of the left subclavian artery. The left innominate vein had developed normally, and the left superior vena cava persisted in rudimentary form, emptying into the coronary sinus.

The embryology of persistent left superior vena cava is briefly discussed. Surgical correction of the coarctation in this instance was not hindered by the venous anomaly.

Three roentgenograms; 3 tracings.

RENE G. FORTIER, M.D.  
St. Paul, Minn.

**Roentgenologic Studies of the Sphincter Mechanism of the Caval and Pulmonary Veins.** Sven Roland Kjellberg and Sten-Erik Olsson. Acta radiol. 41: 481-497, June 1954.

In angiography in children, the authors were struck by the fact that the width of the lumen in the proximal portions of the caval and pulmonary veins undergoes considerable variation. This they felt might

prove to be an important link in the working mechanism of the heart. Accordingly, they investigated the phenomenon in dogs and children by angiography, using a two-plane technic. The injections of various opaque media were made manually into vein of the arm or leg or with a pressure syringe through a Couraud catheter inserted distally into the superior or inferior vena cava. The serial films were taken in the anteroposterior and lateral projections, at the rate of eight and twelve per second.

It was shown that the proximal portions of the inferior and superior vena cava performed movements synchronous with the action of the heart. In the beginning of auricular systole, a rapid contraction took place in the lower 2 to 3 cm. of the superior vena cava and in the upper 1 to 2 cm. of the inferior vena cava. The contractions lasted into diastole. The conditions were identical in the pulmonary veins; however, only those vessels running parallel to the plane of the film could be measured, and then only on 6 occasions. A distinct contraction, however, was observed in a segment approximately 2 cm. long.

The conclusions were that a sphincter mechanism is present at the junction of the caval and pulmonary veins in the auricles. The sphincter mechanism presumably contributes to preventing regurgitation during auricular systole, thereby facilitating transport of the blood from the auricle through the ventricle and modifying the rate of venous flow through the auricle in auricular systole.

Forty-nine roentgenograms, with electrocardiographic tracings. THOMAS E. PADGETT, M.D., University of Louisville

**The Study of Mitral Regurgitation by Roentgen Kymography, with Observations on the Movement of Cardiac Calcifications.** Victor A. McKusick. Am. J. Roentgenol. 71: 961-978, June 1954.

Barium filling of the esophagus represents the most useful and perhaps the most natural method of demonstrating mitral regurgitation by roentgen kymography. Occasionally the left atrium extends over the right heart border and is outlined by lung tissue, which permits observation of the actual atrial movement. Calcification, if present in the wall of the left atrium, can also serve as a contrast medium. The first of these methods is used most widely and the author describes its technic in detail. Kymograms are obtained in the postero-anterior, left anterior oblique, and lateral projections, as well as in the right anterior oblique, which is probably the most useful.

The specific roentgen kymographic finding in mitral regurgitation is an outward movement of the left atrial wall synchronous with the inward movement of the ventricle. This movement of the atrial wall begins slightly before the onset of the main mediad movement of the ventricular border, since regurgitation has its onset during the isometric contraction phase of the ventricle.

The author presents cases of mitral regurgitation with accompanying kymograms obtained by all three methods. In addition, he has attempted to quantitate mathematically the volume of the regurgitant stream by use of the kymogram.

In a critique of the results, the errors which have occurred are analyzed. For the discrepancies between the roentgen appearance and the surgeon's estimate of regurgitation at operation in many cases there is no final explanation. Several hypotheses are presented.

While evaluation of the roentgen kymographic method for the estimation of mitral regurgitation is difficult in the absence of a completely reliable basis of reference, it is considered, in association with the clinical findings, to provide worth-while aid in cases of mitral valve disease. The author definitely believes that there is a specific kymographic pattern associated with this abnormality.

[This is an excellent exposition of roentgen kymography as applied to the mitral valve.—L.A.D.]

Twenty-three roentgenograms; 2 electrocardiograms; 1 diagram; 1 table.

LAWRENCE A. DAVIS, M.D.  
University of Louisville

**The Clinical Picture of Pulmonary Stenosis. (Without Ventricular Septal Defect).** E. Grey Dimond and T. K. Lin. *Ann. Int. Med.* **40**: 1108-1124, June 1954.

Pulmonary stenosis is an extremely common congenital lesion. Surgical repair is possible, and accurate clinical recognition is therefore imperative. The authors, after establishing the diagnosis in 20 cases by cardiac catheterization, sought to correlate the clinical findings to produce an accurate picture of the condition. Characteristic features include a harsh systolic murmur, maximal along the second, third, or even (infrequently) fourth interspace, with a pulmonary second sound which may be normal, reduplicated, or diminished, and an electrocardiogram varying from normal to one indicative of right ventricular hypertrophy. Demonstrable on the roentgenogram or fluoroscopically are a markedly increased systolic pulsation of the main pulmonary artery, in contrast to normal or diminished pulsation of the right and left pulmonary arteries; post-stenotic dilatation; right ventricular or right auricular enlargement. Most of the severe cases show clear pulmonary fields, but generally speaking the lung markings are hard to distinguish from normal. Cardiac catheterization in general indicates a higher pressure in the right ventricle and lower pressure in the pulmonary artery. This procedure is essential for a reliable diagnosis.

Surgery should be based on the following indications:

1. Any clinical symptoms to suggest right heart failure, including episodes of syncope, systolic jugular pulse, systolic pulsations of the liver, etc.
2. A decreasing arterial oxygen saturation, probably indicating that the pressure in the right auricle is mounting and blood is shunting across the foramen ovale from right to left.
3. Change in electrocardiographic pattern with widening of the QRS and increasing amplitude and width of the P waves.
4. An initial right ventricular pressure of 70 or greater.

The most reliable method of evaluating the success or failure of the operation is to catheterize the right heart prior to and after valvotomy through the wound in the right ventricle.

Five figures, including 17 roentgenograms; 2 tables.

STEPHEN N. TAGER, M.D.  
Evansville, Ind.

**Peripheral Angiography.** A. N. K. Menon. *Indian J. Radiol.* **8**: 75-80, May 1954.

This paper is a rather general consideration of peripheral arteriography and venography presented before the Eighth Indian Congress of Radiology. The tech-

niques are described and illustrative cases are briefly reported.

The chief value of arteriography is that it permits a diagnosis of arterial occlusion, determination of the degree of such occlusion, and localization of a possible embolus. It will also reveal the presence or absence of arteriosclerosis, aid in the diagnosis of peripheral and arteriovenous aneurysms and malignant tumors, and provide information as to the circulation around arthritic joints and areas of osteomyelitis.

In thromboangiitis obliterans, the arteriographic findings include: absence of atheroma or calcification of the intima and of intimal thickening, total occlusion of the artery, and an extensive collateral circulation beyond the site of obstruction.

In arteriosclerosis there are intimal calcification and thickening, the latter showing a characteristic distribution in the femoral and popliteal arteries. The branch arteries are constricted at their origin, and the thickened intima encroaches upon the lumen ("intimal cushion").

A localized peripheral aneurysm will cause an abrupt enlargement of the contour of the artery. Spastic conditions are differentiated from organic disease by absence of occlusion. Abnormal increases of circulation are demonstrable in the presence of a malignant lesion. In osteomyelitis the vessels over the site of involvement will show dilatation, and contrast material will collect in the large spaces within the bone structure.

Aortography is useful in cases of total thrombosis of the femoral artery extending into the iliac artery, where peripheral angiography cannot be done. In abdominal conditions it is used for location of an organ, diagnosis of arterial obstruction and aneurysm, and demonstration of renal neoplasms which evade detection by pyelography.

Venography demonstrates the deep venous circulation if the veins are patent, but not if they are blocked. Spleno-venography is a special technic for the diagnosis of obstruction of the portal vein.

Six roentgenograms.

G. M. RILEY, M.D.  
Shreveport, La.

**A Contribution to Phlebography in Acute Circulatory Disturbances of the Lower Extremities.** K.-G. Eysoldt. *Fortschr. a. d. Geb. d. Röntgenstrahlen* **80**: 714-723, June 1954. (In German)

Phlebography has not enjoyed the same popularity as arteriography, mainly because the venous system is not easily filled in all its branches with contrast material and the findings are not so easily interpreted. In thrombophlebitis of the subcutaneous veins of the lower extremities phlebography is unnecessary because the diagnosis can easily be made by inspection and palpation. If, however, a thrombophlebitis of the deep veins is suspected, phlebography is the only diagnostic procedure that can give exact information about the existing condition and the location of the obstruction. The author has for many years employed the technic of G. Bauer [See *Acta radiol.* **26**: 577, 1945. Abst. in *Radiology* **47**: 430, 1946], which uses as the site of injection the vena saphena parva. If this vein is injected with contrast material in a healthy patient, the entire deep system of veins up to the inguinal region can be well demonstrated.

The patient is placed in a horizontal position. The heel of the diseased leg is slightly elevated so that there

is no compression of the veins in the calf, and the leg is slightly rotated inward (about 30 to 45 degrees). Through an incision measuring 2 or 3 cm. along the upper edge of the outer malleolus, the vein is exposed. A mixture consisting of 20 c.c. of a 30 per cent and 10 c.c. of a 70 per cent solution of Joduron, to which has been added 1.0 c.c. of a 10 per cent solution of Novocaine, is slowly injected under constant pressure in sixty to ninety seconds. Toward the end of the injection, when the last cubic centimeter of the contrast material enters the vein, the film is exposed. Only one anteroposterior view is taken, at a film-focal-spot distance of 2 meters, on a film measuring 20 X 96 cm.

If the injection were made into the vena saphena magna the medium would enter the superficial veins, and the deep veins would be only partially filled. The pressure difference between the deep and the superficial systems is such that, when the vena saphena parva is injected, the contrast material will first fill the entire system of deep veins up to the inguinal region. Only if there is an obstruction in the deep veins, or if the injection is made under too great pressure and too rapidly, will the medium spill over into the superficial veins. If, therefore, none of the superficial veins are visualized, an obstructive lesion in the deep veins can be excluded.

The valves of the veins are well demonstrated by this method and are easily recognized by the ballooning of the contrast material. Wherever tributaries of the veins branch off, the contrast shadow in the main stem may be a little lightened. This should not be misinterpreted as representing a thrombus. For a definite diagnosis of thrombosis, the thrombus must be demonstrated with the contrast material surrounding it. If the thrombus completely occludes the vein, only the head or tail may be demonstrable. In such cases the convex appearance of the contrast shadow suggests the diagnosis.

The collateral veins should be carefully watched. As the resistance in the main stems of the deep veins increases through pathological processes (thrombosis), the valves to the superficial veins are gradually opened and these veins become filled. Of great importance are the veins of the two heads of the gastrocnemius muscle, the so called vena suralis medialis and lateralis. They empty into the popliteal vein in the popliteal space just as the deep veins of the lower leg do. If the deep veins of the lower leg are partially occluded, the two venae surales take over and carry the blood into the popliteal vein before an edema of the lower leg develops. Only if the occluding process has reached the popliteal vein and blocks the venae surales, will edema of the ankle occur.

Phlebography is indicated if clinically a thrombosis cannot be excluded with certainty; also to study unilateral edema and to determine the exact location of a thrombus.

Eighteen roentgenograms.

WILLIAM A. MARSHALL, M.D.  
Chicago, Ill.

#### THE DIGESTIVE SYSTEM

**Effect of Tea on Gastric Secretions and Motility.** C. Wilmer Wirts, Martin E. Rehfuss, William J. Snape, and Paul C. Swenson. *J.A.M.A.* 155: 725-729, June 19, 1954.

Tea is reported to contain tannin and caffeine in a ratio of 3:1; it also contains minute quantities of vola-

tile oils, certain trace elements and B vitamins, water-soluble derivatives of tannin, chlorophyll, proteins, and various carbohydrates. Probably because tannin is often erroneously considered synonymous with tannic acid, there has been an impression that large amounts of tea may exert a deleterious effect on digestion by precipitating proteins and albuminoses and thereby lessening absorption and irritating the gastric mucosa. The authors' investigations included both *in vitro* experiments and observations on man.

*In vitro*, tea mixed with gastric juice had only a slight effect on free and total acid, pepsin, and pH. The effects differed very little from those obtained by mixing gastric juice with water.

Twelve patients who had duodenal ulcers in a state of remission were studied after receiving through a gastric tube the equivalent of two cups of hot tea, and again, as a control, after being given an equal amount of hot water. Little difference in the pH of the gastric contents over a two-hour period (as determined by aspiration) resulted, but the free-acid content was a little higher and the pepsin values slightly less after tea than after water.

Gastric emptying was observed in patients by measuring the gastric material obtained by aspiration every half hour for two hours, the aspirated contents being reinjected into the stomach on each occasion. Actual meals were simulated by use of 40 per cent fat, 40 per cent peptone, 40 per cent carbohydrate, or a combined fat-protein-carbohydrate meal composed of eggnog. Each patient was tested on different days by injecting with the meal, hot tea, hot water, iced tea, or iced water. Tea produced a slight but definite increased rate of gastric emptying as compared with water; for both tea and water, emptying was considerably accelerated when the beverage was iced.

Gastric emptying was also observed fluoroscopically after adding barium to fat and tea, and on another day to fat and water. Thirteen patients were given their beverages hot; 3 were served with iced beverages. The average emptying time with hot tea was 266 minutes, with hot water 327 minutes, with iced tea 193 minutes, and with iced water 250 minutes.

An intragastric balloon connected to a kymograph was used in 4 patients. Water was found to obliterate motility, while tea stimulated peristaltic action considerably.

The authors believe that their study corroborates the long-held belief that a cup or two of tea with meals has value in aiding digestion and relieving postprandial distress.

Three illustrations; 3 tables.

ARTHUR S. TUCKER, M.D.  
Cleveland Clinic

**Roentgenological Diagnosis of Alimentary Tract Emergencies in the New Born.** Kakarla Subbarao. *Indian J. Radiol.* 8: 64-74, May 1954.

Next to birth trauma, congenital anomalies are the commonest cause of death in the newborn. Prompt recognition and adequate surgical correction of such anomalies will result in a gratifying decrease in the mortality rate. The author considers in turn the following: esophageal atresia, forked or annular pancreas, intestinal atresia or stenosis, meconium ileus, meconium peritonitis, atresia of the rectum associated with imperforate anus, diaphragmatic abnormalities, omphalo-

ter-  
and  
1 is  
anic  
ts of  
pre-  
sen-  
The  
peri-

ly a  
pH.  
l by

te of  
stic  
n, as  
hot  
con-  
pira-  
ittle  
than

meas-  
ation  
con-  
occas-  
9 per  
rate,  
posed  
days  
1 tea,  
le in-  
with

ider-

ically  
er day  
their  
ages.  
min-  
a 193

graph  
oliter-  
con-

es the  
ls has  
andial

.D.  
inic

Tract  
barao.

re the  
prompt  
f such  
the mor-  
rowing:  
as, in-  
onium  
imper-  
phalo-

cele, and such miscellaneous conditions as malrotations and reduplications of the gastrointestinal tract, faulty mesenteric attachments, and pericardiophrenic herniation. The observations are general in nature, including brief consideration of the roentgenological criteria for diagnosis and illustrations of some surgically proved cases.

Twelve roentgenograms.

**The Fate of Bismuth Carbonate in the Stomach. A Radiological Study.** F. Pygott. *Lancet* 1: 1314-1316, June 26, 1954.

The therapeutic value of an alkali in the treatment of peptic ulcer appears to depend upon at least six factors: chemical efficiency of the alkali; the absence of any after-secretion effect; the persistence of the alkali in the stomach under varying conditions; any protective effect it may have by adhering to the gastric mucosa, thus providing neutralization of hydrochloric acid as it is secreted; any physical or chemical protective effect that it may have by persisting in the crater of an ulcer; and the absence of any undesirable side-effects. The author describes a radiological investigation of three of these factors, namely, persistence in the stomach, adherence to the gastric mucosa, and retention in peptic ulcers. Six tests were employed on normal persons as follows: (1) After the usual preparation for a barium meal examination, the subject was given bismuth carbonate, 20 gm. in 2 oz. of water. (2) A few minutes following the administration of bismuth carbonate, as in Test 1, the subject drank 6 oz. of water. (3) The bismuth carbonate was given on an empty stomach and followed by one egg beaten up in milk to a total volume of 6 oz. (4) The bismuth carbonate was followed by an ordinary mixed meal. (5) An ordinary mixed meal was eaten by the fasting subject, after which the bismuth carbonate was given. (6) A mixture of 20 gm. of bismuth carbonate in 6 oz. of milk was given.

In patients with gastric ulcer Test 2 was omitted, and in those with duodenal ulcer Tests 4 and 5 only were used.

The retention of a significant quantity of the 20-gm. dose of bismuth carbonate was found to vary greatly from person to person under the same conditions. In a healthy person, the retention was greatest when the bismuth was given in a milk mixture. Ten of the 20 patients with gastric ulcer retained half the test dose in the stomach for an hour, irrespective of the method of administration. Three of 9 patients with duodenal ulcer retained half the test dose for an hour. Persistent coating of the gastric mucosa for an hour occurred only once in the 20 patients with gastric ulcer and did not occur at all in the 9 with duodenal ulcer. It is thus unlikely to be an important factor in the effectiveness of the alkali.

Retention of the bismuth carbonate was maximal when it was given in milk or was followed by egg and milk. In duodenal-ulcer patients retention in the stomach is also more likely if the alkali is given after a meal.

**Roentgenologic Problems in Ulcers About the Pylorus.** Joseph McK. Ivie and John H. Beveridge. *South. M. J.* 47: 530-537, June 1954.

In a small percentage of cases, an ulcer is so close to the pylorus that on initial x-ray examination it is impossible to be absolutely certain whether it is gastric or duodenal. In order that unnecessary surgery may be

avoided, it is of prime importance that every means possible should be taken to make the correct diagnosis. Although the pathologic changes which create this confusion are difficult to evaluate, some form of spasm in the first portion of the duodenal cap with or without pylorospasm can explain the roentgenologic changes. In the authors' experience, re-examination of the patient after a week or ten days of intensive ulcer therapy almost always reveals the true site of the ulcer niche. The most ardent advocates of immediate surgery should not object to this delay in deciding the course of treatment.

The authors present 6 cases in which the clinical impression on the initial x-ray examination was prepyloric gastric ulcer. At a later x-ray examination or at operation these ulcers were found to be in the duodenum. In 4 cases there was no pyloric spasm. Instead, the pylorus was atomic and hung open throughout the examination. Spasm was apparently present in a circular band about the base of the duodenal cap, with no obvious roentgen deformity of the cap. This circular spasm adjacent to the pylorus so resembled the normal pylorus that the ulcers with their associated edema appeared to be gastric rather than duodenal. In 2 cases the ulcer was associated with pylorospasm. In addition, a smooth band of spasm about the base of the duodenal cap gave the roentgen appearance of an elongated pylorus with an ulceration, which was confused with a prepyloric lesion.

Thirteen roentgenograms.

**Dysphagia in Bulbar and Pseudobulbar Lesions Simulating Oesophageal Carcinoma.** Erik Madsen. *Acta radiol.* 41: 517-524, June 1954.

Seven of 108 patients referred to the Radium Center, Copenhagen, between 1940 and 1950 for suspected carcinoma of the esophagus had bulbar or pseudobulbar lesions. A frequent clinical finding was dysphagia. Paresis of the soft palate, in some cases involving the pharynx and vocal cords, and atrophy and paresis of the tongue were other common findings. These bulbar conditions may be caused by bulbar palsy, that is, amyotrophic lateral sclerosis of bulbar situation or Wallenberg's syndrome (thrombosis in the posterior interior cerebellar artery). There may also be a question of encephalitis, poliomyelitis, tumors, traumatic lesions, and cerebral arteriosclerosis as etiological agents.

Roentgen examination of these patients revealed one or more of the following signs: (1) passage of barium into the larynx and trachea, (2) retention of the contrast medium in vallecular and piriform sinuses, (3) accumulation of contrast medium in the pharynx, and (4) delayed passage of barium down the esophagus. Occasionally the esophagus may show circular areas of spasm, and in these cases the condition may be difficult to distinguish from organic stenosis. However, on further examination the spasm at certain times relaxes spontaneously.

Three roentgenograms. CLAUDE D. BAKER, M.D.  
University of Louisville

**Peristalsis in Reversed Loops of Bowel.** A. O. Singleton, Jr., and E. B. Rowe. *Ann. Surg.* 139: 853-857, June 1954.

To determine the importance of maintaining the continuity of the bowel in the original direction in the

performance of anastomoses, the authors carried out experiments on dogs, transecting loops of bowel of varying length and replacing them in reversed position. On subsequent examination, dilatation and hypertrophy were always observed proximal to the proximal anastomosis, and in the reversed loop peristaltic waves appeared to be following their original direction, opposite that in the rest of the bowel.

The conclusion is naturally reached that it is very important to maintain the normal continuity of bowel at surgery. A case is reported, however, in which use of an antiperistaltic loop of colon was successfully used to bridge an esophageal defect. Gravity and intermittent passage of food are offered as explanations of the success of this procedure in spite of the experimental findings.

Three roentgenograms; 2 photographs.

ZAC F. ENDRESS, M.D.  
Pontiac, Mich.

**Tumors of the Small Intestine.** Leo H. Pollock. Am. J. Surg. 87: 851-859, June 1954.

The author reviews the symptoms, pathology, and surgical treatment of tumors of the small intestine and adds 2 cases to the literature, an adenocarcinoma and a pedunculated submucous lipoma. Both of these tumors occurred near the ligament of Treitz.

According to some authorities, up to 90 per cent of tumors of the small bowel may be suspected upon the basis of adequate x-ray examination. Although other lesions may simulate tumors in some respects, the neoplastic filling defects are generally sharply demarcated at both the proximal and distal margins and involve a short segment. There is alteration or obliteration of the mucosal pattern at the site of the lesion, and there may be obstruction and ulceration. Tumors in the submucosa expand the mucosa to iron out or obliterate the mucosal pattern. In the early stage of obstruction, such as that produced by a constricting neoplasm, dilatation may not be pronounced and can be demonstrated for only a short distance proximal to the tumor. The characteristic appearance of obstruction with severe dilatation is usually absent unless the obstruction be of sudden onset, such as that produced by intussusception of a polypoid tumor. This is due chiefly to the fact that the small intestine has the inherent ability to compensate for a gradual reduction in the diameter of the lumen.

There is no reliable roentgenologic evidence of the benign character of a demonstrated tumor. In spite of the accepted morphologic criteria of benignity—a circumscribed tumor regular in contour—microscopic examination of the lesion may show it to be malignant.

A small-bowel enema produces filling of the entire small intestine to disclose filling defects. A small duodenal tube may be used to control the instillation of the barium suspension. While serial films require much time, they may disclose a tumor which would otherwise have been missed. Lesions of the lower ileum may be revealed by reflux through the ileocecal valve during a barium enema. In leiomyoma there often is a central niche due to necrosis.

Statistically the most common tumor of the small bowel is carcinoma, followed in incidence by benign tumors and then carcinoids.

Three roentgenograms; 1 photograph; 2 photomicrographs.

WINSTON C. HOLMAN, M.D.  
Shreveport, La.

**Acute Obstructions of the Colon.** Marshall L. Michel, Jr., Clarence T. Thompson, Harry W. Reinsteine, Jr., Robert R. Senter, and David B. Dale. Ann. Surg. 139: 806-815, June 1954.

Obstruction of the colon, though it occurs much less frequently than obstruction of the small bowel (1:5 in the institutions from which this report comes), carries a rather high mortality. In 237 cases seen in 1941-52 there were 57 deaths (24 per cent). Delay in treatment on the part of the patient and physician and errors in diagnosis and therapy account in large part for the mortality.

Carcinoma, diverticulitis, and volvulus are the main causes of colonic obstruction. Two hundred cases attributable to these conditions form the basis of this paper.

Obstruction of the colon differs fundamentally from obstruction of the small bowel, and if diagnostic and therapeutic errors are to be avoided, this must be kept constantly in mind. In 46 cases of carcinoma in the present series, the condition had been erroneously diagnosed prior to admission, invariably as a result of inadequate investigation. Post-admission diagnostic errors were due chiefly to the absence of distinctive clinical features. Fifty-three patients passed gas or feces after the onset of symptoms, and in 37 vomiting did not occur.

The most serious errors in diagnosis in the 103 cases reported up to 1948 arose from failure to employ roentgenologic procedures, particularly barium enema studies, or from incorrect interpretation of the roentgen findings. In the 97 cases seen after that time, roentgen examination was still not done as often as it should have been, but scout films were taken more frequently and the level of obstruction was usually reported more specifically. This was reflected in the difference in mortality—29 per cent in the earlier and 16.5 per cent in the later group.

The authors especially stress the importance of the barium enema, repeating the truism that while barium by mouth is dangerous and useless in these cases, barium by rectum is harmless and useful. In 33 of the 97 cases seen after 1948 in which the procedure was used, the interpretation was invariably correct, and in this number there was only a single fatality, which was in no way related to the examination.

Treatment is considered at length. Use of the Miller-Abbott tube is strongly condemned. It was used in 37 cases (mostly before 1949) with 17 fatalities. It is concluded that "better results would be achieved if surgery were performed more promptly, even when a precise clinical diagnosis could not be made, and if emergency surgery were limited to decompression of the bowel by the simplest method possible. Primary resection is only occasionally indicated, in very carefully selected cases of malignant obstruction. Conservative therapy is disastrous."

One drawing; 4 graphs; 3 tables.

ZAC F. ENDRESS, M.D.  
Pontiac, Mich.

**The Causal Relationship Between Benign Epithelial Tumors and Adenocarcinoma of the Colon and Rectum.** K. A. Hultborn. Acta radiol. Supplement 113, 1954.

The author expresses the opinion that the majority of carcinomas of the rectum and colon develop from benign epithelial tumors (polyps). Various factors are mentioned which tend to support this view. The ap-

parently irreconcilable facts that carcinomas are relatively more numerous in the rectum and sigmoid, and benign epithelial tumors in the proximal segments of the large bowel, may possibly be explained by the so-called hit theory of Iversen and Arley (*Acta path. et microbiol. scandinav.* **27**: 773, 1950), which is based on results of biological experiments with carcinogenic agents.

According to this theory, the biological processes in question are controlled by a certain center in the nucleus of the cell, which is thought of as a giant molecule. This control center may be excited to make a "quantum transition" to a new state. The occurrence of a tumor is thus thought of as a function of the induced increase of the proliferation rate. The transition of a cell to a carcinoma does not occur directly, but only if the center is excited twice. The probability of hitting a control center is proportional to the size of the area to which the carcinogen is applied, and the higher the concentration of the applied agent, the greater the chance to effect a transition of a cell to a higher level (i.e., formation of a carcinoma).

In applying this theory to intestinal tumors, it is postulated that a hypothetical carcinogenic agent, causing tumors to develop in the bowel, is concentrated, like the feces, in the anal direction. In the colon, and particularly the ascending portion, the concentration is low. Because the surface area is large, there is less possibility of more than one hit by the carcinogenic agent at the same site; in the rectum, where the concentration is higher and the surface area smaller, the chances of a double hit are greater. This would explain the relatively greater number of carcinomas in the rectum and of benign epithelial tumors in the colon. The hypothesis is supported by the clinical observation of the impossibility of judging the prognosis in benign epithelial tumors, since according to this theory any malignant transformation of the tumor is purely a matter of chance.

With regard to the practical possibilities of reducing the morbidity in carcinomas of the colon and rectum by removal of benign epithelial tumors, a distinction has to be made between those regions of the intestine that are within and beyond the range of the sigmoidoscope. In the author's opinion, all benign epithelial tumors—both symptomatic and asymptomatic—detected in the rectum and sigmoid should be removed, for the tendency to malignant transformation is greatest in those parts of the bowel and removal is technically simple and without risk. The question is left open as to whether detection of these benign epithelial tumors justifies investigation of apparently healthy persons or should be limited to sigmoidoscopic examination of persons with intestinal symptoms. In the author's opinion there is much in favor of the latter procedure.

Twenty-three cases are reported in some detail.

Seventy-eight illustrations, including 27 roentgenograms.

**Teridax, a New Cholecystographic Medium.** C. Rowell Hoffmann. *Am. J. Digest. Dis.* **21**: 150-152, June 1954.

Cholecystography with Teridax (ethyltriiodoethionic acid) was performed in 96 patients. In 66, excellent cholecystograms showing normally functioning gallbladders were obtained. In 30 cases there was poor visualization or non-visualization of the gallbladder even with repeated dosages. These cases were re-

examined with either Priodax or Telepaque, and the gallbladder was not demonstrated. All of the 30 patients were found at surgery to have abnormalities which explained the non-visualization.

The density of the shadow obtained with Teridax was measured photometrically and found to be between that observed with Priodax and that seen with Telepaque.

In the author's hands, Teridax produced a lower incidence of discomforting side reactions than any other medium employed to date.

Unabsorbed radiopaque material in the large bowel was not observed in any patient receiving a single dose of Teridax. In a few cases small amounts of unabsorbed material were observed in the colon following repeated doses, but these small opacities did not obscure or confuse the interpretation of the gallbladder shadow.

### THE DIAPHRAGM

**Transdiaphragmatic Eventration of Peritoneum Secondary to Pneumoperitoneum.** Jacob E. Orritt and Leroy Hyde. *Am. Rev. Tuberc.* **69**: 1045-1050, June 1954.

A case is reported in which a bleb (diaphragmatic pneumocele) was noted ten months following induction of a therapeutic pneumoperitoneum for pulmonary tuberculosis. The lesion presented as a thin-walled cyst-like air-filled cavity at the right posterior base. Exploration showed it to be a herniation of peritoneum through a 1.0-mm. defect in the diaphragm; it was lined by mesothelium on both surfaces.

The authors believe that these herniations occur through defects in the diaphragm and are likely to rupture, resulting in tension pneumothorax, which may be fatal. They advise surgical excision with repair of the defect, which is usually at or near the pleuroperitoneal hiatus (foramen of Bochdalek).

Seven roentgenograms; 1 photograph; 2 drawings.

JOHN H. JUHL, M.D.  
Minneapolis, Minn.

### THE MUSCULOSKELETAL SYSTEM

**Normal Bone, Diseased Bone, Dead Bone. Caldwell Lecture, 1953.** Paul C. Hodges. *Am. J. Roentgenol.* **71**: 925-940, June 1954.

In a lecture delivered before the American Roentgen Ray Society, the author presents a historical review of the development of present-day knowledge of the physiology of bone and its practical application in the study of normal living bone, various types of diseased bone, and finally necrotic or dead bone. In conclusion, he points out that we are only just beginning to find out how much we do not know about the formation, growth, disease, and death of bone.

Twenty-four roentgenograms; 2 photographs.

CLAUDE D. BAKER, M.D.  
University of Louisville

**Variations in Clinical Manifestations of Osteopetrosis. Report of Two Cases.** Andrew F. Turano, Katharine Antoinette Fagan, and Paschal A. Corbo. *J. Pediat.* **44**: 688-694, June 1954.

Osteopetrosis is a rare developmental disease of bone, varying widely in its clinical manifestations. Because of the typical bone changes, the diagnosis is usually

made roentgenologically. Two forms are recognized, malignant and benign. The malignant type produces severe and progressive anemia, thrombocytopenia, hepatosplenomegaly, blindness, and profound bone changes. In the benign type there are malnutrition and retardation of growth and development. An example of each is presented.

In the patient with the malignant form of osteopetrosis, the serum acid phosphatase was consistently elevated. While the significance of this finding is not known, it is believed that acid phosphatase activity in osteopetrosis should be further investigated.

#### Five roentgenograms.

**Familial Acro-osteolysis.** I. Harms. *Fortschr. a. d. Geb. d. Röntgenstrahlen* **80**: 727-732, June 1954. (In German)

Familial acro-osteolysis is a rare disease, only 72 cases having been reported up to 1952 (Giacciai: *Acta radiol.* **38**: 17, 1952. Abst. in *Radiology* **60**: 776, 1953). It is hereditary, the inheritance being of the dominant type. Men are involved three times as frequently as women.

Clinically, the disease begins with the formation of a swelling or blister along the plantar surface of the foot. Slowly an ulcer develops, gradually increasing in size and depth. Pieces of bone are ejected and the ulcer usually heals, only to recur after a few weeks or months. In the course of years the disease may involve both feet. The general condition of the patient is little disturbed and pain is slight or absent, though there are disturbances in sensibility of the feet and lower legs and sometimes also of the hands and forearms.

The bony changes as seen on the x-ray films are characteristic. They appear first in the distal and medial portions of the feet and gradually progress proximally. The process is purely osteolytic, with no signs of bone regeneration. Occasionally, due to secondary infection in the presence of an ulcer, an osteomyelitis develops, which after some time heals. Gradually the phalanges are destroyed, then the head of the metatarsal bones. The shafts of the metatarsals assume a pencil-point appearance. The epiphyses are able to resist the destructive changes a little longer.

The prognosis as to life is good, but as to recovery it is unfavorable. There is no known treatment.

The etiology has not been studied very carefully because, according to the literature, only 2 postmortem examinations have been made. A lesion of the intraspinal nerve tract such as occurs in tabes dorsalis, in syringomyelia and in tumors of the spine, does not occur in familial acro-osteolysis. Giacciai believes that the disease is caused by a lesion of the peripheral nerve fibers.

The acro-osteolysis of Harnasch (*Fortschr. a. d. Geb. d. Röntgenstrahlen* **72**: 352, 1950. Abst. in *Radiology* **56**: 303, 1951) differs from familial acro-osteolysis in that the nails remain intact, ulcers do not occur, and there are no disturbances in sensibility.

#### Eight roentgenograms.

WILLIAM A. MARSHALL, M.D.  
Chicago, Ill.

**Punctate Epiphyseal Dysplasia (Chondrodystrophy Calcificans Congenita). Report of a Case with Nine Year Period of Observation.** Lester W. Paul. *Am. J. Roentgenol.* **71**: 941-946, June 1954.

Punctate epiphyseal dysplasia is a rare disorder of

bone growth, known also as chondrodystrophy calcificans congenita and chondroangiopathia calcarea seu punctata. It is characterized by the presence of multiple small calcific areas within the hyaline cartilages, giving them a stippled appearance. These probably develop during intrauterine life, since they are present at birth. Very frequently the condition is associated with other congenital abnormalities of a chondrodystrophic type. In those infants who survive, the calcifications have been found to disappear, giving place to normal centers.

The author describes a case observed over a period of nine years. At the age of one month tiny areas of calcification were demonstrable in all the cartilaginous areas of the spine and other portions of the skeleton. They were most numerous in the epiphyses of the right lower extremity, which was shorter than its mate. At twenty-one months of age almost all the abnormal calcific foci had disappeared. At nine years of age their disappearance was complete, but the right lower extremity was shortened and there was a moderate scoliosis of the spine. In other respects the child was normal.

Because of their rapid disappearance, these foci are held not to represent normal foci of ossification in multiple form. The gross defects noted in the literature and in the author's case are presumed to be associated anomalies, not attributable to the presence of the stippling *per se*. The condition may be an abortive type of achondroplasia. In the author's case, the chondrodysplastic tendency was limited to a few of the dorsal vertebrae and the right lower leg.

#### Twelve roentgenograms.

LAWRENCE A. DAVIS, M.D.  
University of Louisville

**Cat-Scratch Disease Associated with an Osteolytic Lesion.** William C. Adams and Sarah M. Hindman. *J. Pediat.* **44**: 665-669, June 1954.

The authors report a case of cat-scratch disease in a 5-year-old boy, who was admitted to the hospital with a "gland in his neck," fever, and pain in the right hip. The diagnosis of cat-scratch disease was based upon the clinical pattern, the histologic appearance of a cervical lymph node, and a positive skin reaction to cat-scratch antigen. Roentgen examination of the hip revealed a radiolucent area, 13.0 X 7.0 mm., along the margin of the right ilium. There was no evidence of fracture at the site of the lesion, and no peripheral condensation of bone. The appearance suggested an eosinophilic granuloma or a tuberculous or non-specific osteomyelitis. During the period of hospitalization, which lasted approximately one month, the patient's condition steadily improved. Roentgenograms of the ilium at the time of discharge showed early healing of the osseous lesion. Serial films approximately seven months later demonstrated complete healing.

While the relationship of the osteomyelitis in the ilium to the cat-scratch disease is not established, in view of the increasingly apparent protean nature of the latter disease the possibility of a causal association must be considered.

Two roentgenograms; 2 photomicrographs.

**A Case of Hemangio-Endothelioma of the Skeleton.** J. E. J. Resink. *Fortschr. a. d. Geb. d. Röntgenstrahlen* **80**: 732-738, June 1954. (In German)

Malignant hemangioendothelioma may take its

origin anywhere in the system where blood vessels are present. However, its localization in the skeleton is rare. There is nothing particularly characteristic in the x-ray findings, and the diagnosis depends upon microscopic study, with the demonstration of malignant cell proliferation and newly formed blood vessels. Differentiation from angiosarcoma may be difficult and, indeed, transitions from one to the other may occur.

Radiologically there is a cyst-like bone defect, usually in the long bones, with some trabeculae and invasion of the soft tissue. The tumor may occur at any age. It is manifested clinically by pain and swelling, over which a pulsation can often be felt; on auscultation a murmur is audible. Multiple defects are usually indicative of metastatic spread. Metastasis is frequent and is mostly hematogenous, seldom by way of the lymph channels. The prognosis is poor. The tumor is not sensitive to irradiation and is best treated by radical amputation.

The author reviews the literature and reports a case of his own in which an amputation of the leg was done and the diagnosis was confirmed by microscopic examination.

Three roentgenograms; 4 photomicrographs; 1 photograph. WILLIAM A. MARSHALL, M.D., Chicago, Ill.

**Secondary Chondrosarcoma.** Bradley L. Coley and Norman L. Higinbotham. Ann. Surg. 139: 547-557, May 1944.

A cartilage tumor may be benign or malignant. The benign group includes: central chondroma (enchondroma), peripheral chondroma (osteochondroma), and mixed forms which present involvement of both cortical and cancellous bone. The term *secondary chondrosarcoma* is used to designate malignant transformation of a benign cartilage tumor. Such transformation should be suspected when pain is experienced in a previously symptomless cartilage tumor, when the growth of the latter is accelerated, or when roentgen examination reveals changes that are suggestive. The authors lay great stress on the roentgen picture, though they do not describe this in any detail. It is their belief that a diagnosis of chondrosarcomatous change is often justified by the clinical and roentgenographic findings without the histologic confirmation so essential when dealing with most malignant neoplasms.

When a benign cartilage tumor is first discovered, the decision for early surgical removal must be carefully considered, for such a procedure may in reality constitute cancer prevention. Incomplete removal, which often happens, does not eliminate the possibility of future malignant alteration.

Surgery is the only treatment for chondrosarcoma. The authors report on 52 cases so treated. Thirty patients are living and 22 are dead. Seven of the living are known to have metastases and obviously will eventually succumb to the disease. The average survival period of the 30 living patients is four and a half years. One patient died of sarcoma eighteen years after an amputation for chondrosarcoma of the tibia. Two operative deaths occurred. Seven patients are living with disease, the duration averaging 2.6 years. Twenty-three patients are well without evidence of disease with an average survival of five years. Two of these are well seventeen years; another sixteen years.

A detailed analysis of 52 cases is presented in tabular form.

Eleven illustrations, including 3 roentgenograms; 3 tables.

HARRY HAUSER, M.D.  
Cleveland City Hospital

**Radiographic and Anatomic Studies of the Parasternal Ossification Centers.** Nicola Ludovico. Radiol. med. (Milan) 40: 529-537, June 1954.

Small round bony shadows, sometimes bilateral, may be observed at the level of the upper corner of the manubrium sterni. The laminographic methods demonstrate them satisfactorily, but they can be seen also in routine x-ray films. These shadows are not too rare (about 5 per cent of the cases studied by the author). Histologically they reproduce the typical morphology of ossification centers. They may represent accessory foci of ossification of the sternum or they may belong to the adjacent ends of the ribs. In most cases they are the expression of osteoblastic activity of the most anterior portion of the rudimentary fibrous cervical ribs. It is important to keep in mind the existence of these anomalies. When they are unilateral, they may simulate parenchymal pulmonary calcification. They may also be mistaken for traumatic diastasis of the manubrium or myositis ossificans following trauma.

Fourteen roentgenograms; 5 photographs; 2 photomicrographs. R. G. OLIVETTI, M.D.  
Newington, Conn.

**Case Report: Klippel-Feil Syndrome.** Hubert H. Bloch. South African M. J. 28: 511-513, June 19, 1954.

The essential feature of the Klippel-Feil syndrome is the congenital fusion of two or more cervical vertebrae, but associated anomalies are usually present, the most common being spina bifida of the cervical vertebrae. Elevation of the scapula, the so-called Sprengel's deformity, is also so common that it is regarded by some as part of the syndrome.

The author reports what he believes to be the sixtieth case of Klippel-Feil syndrome to be recorded in the English literature. In addition to a harelip, which had been repaired, the patient had asymmetry of the cranial vault with some degree of platybasia, fusion of the 1st and 2d and 3rd and 4th cervical vertebrae and partial fusion of the 6th and 7th, with narrow disks between the 2d and 3rd and 4th and 5th; spina bifida of the lower cervical spine; irregularity in size of the vertebrae; absence of the pedicle of the 4th vertebra; a right cervical rib arising from the 7th vertebra; upper thoracic scoliosis and elevation of the left scapula. Three roentgenograms; 2 photographs.

**Whiplash Fractures of Cervicodorsal Spinous Processes. Resemblance to Shoveler's Fracture.** J. Gershon-Cohen, Earl Budin, and Frank Glauser. J.A.M.A. 155: 560-561, June 5, 1954.

Among 480 x-ray examinations of the neck, 38 cases were found with isolated or multiple calcareous deposits or fragments near the cervicodorsal spinous processes. The sex distribution was almost equal (18 females, 20 males). A history of an automobile collision was elicited in 14 cases. The fractures appear identical with those described in the literature (principally German) as "clay-shoveler's fractures," but not a single shoveler was found among the

authors' patients. The mechanism of production is considered to be hyperflexion which, in most instances, results from sudden deceleration (front-end automobile collision); in an occasional case, the precipitating factor is considered to be over-correction of a whiplash hyperextension from sudden acceleration (rear-end automobile collision). In support of these hypotheses, the authors were able to produce similar fractures of the lower cervical spine in cadavers by sudden sharp bending of the neck.

Six roentgenograms. ARTHUR S. TUCKER, M.D.  
Cleveland Clinic

**Cervical Spondylosis. Incidence and Implications.** Christopher Pallis, Arthur M. Jones, and John D. Spillane. *Brain* 77: 274-289, June 1954.

In an attempt to obtain more information about asymptomatic cervical spondylosis and the early involvement of the nervous system, 50 patients in the medical and surgical wards of a teaching hospital, all fifty years of age or over, were examined clinically, and roentgenograms of the neck (anteroposterior, lateral, 2 oblique) were taken. Patients whose presenting symptoms were "neurological" were excluded from the survey.

Of the 50 persons examined, 70 per cent showed narrowing of the spinal canal due to various combinations of posterior osteophytosis, subluxation of cervical vertebrae, and loss of cervical lordosis. After fifty, neither the incidence nor the severity of canal narrowing appeared to increase significantly. Some 40 per cent of the patients with narrowing of the spinal canal showed physical signs suggestive of cord involvement. After the age of sixty-five, the incidence rose to 75 per cent.

Seventy-five per cent of the patients showed narrowing of the intervertebral foramina due to osteoarthritis at the neurocentral and apophyseal joints, but no increase in this narrowing with age was observed after fifty. Forty per cent of the patients with foraminal narrowing showed signs suggestive of root involvement.

On clinical examination, abnormalities of the neck were found in 40 per cent and neurological abnormalities in 60 per cent of the cases. Few patients had complaints suggestive of a nervous disorder.

The authors conclude that cervical spondylosis is clearly a common disease in elderly people. Its particular importance, however, lies in the fact that involvement of the spinal cord and nerve roots may occur in a silent manner. Neurological signs may precede the development of symptoms. Certain notions about the neurology of old age require reconsideration in this light. Moreover, this concept may be of importance in explaining the unexpected, and apparently irrelevant, occurrence of cord signs in certain elderly patients.

Five roentgenograms; 6 tables.

**Calcified Intervertebral Disc in Children and Adults.** S. Schorr and E. Adler. *Acta radiol.* 41: 498-504, June 1954.

The authors discuss the difference between intervertebral disk calcification in children and adults and describe a case in an 8-year-old boy. Following a fall, the child experienced severe pain in the neck and marked torticollis. Roentgen examination six days later showed a compression fracture of the 6th cervical vertebra with marked calcification of the nucleus pul-

posus of the disk between C-6 and C-7. Immobilization of the fracture was followed by subsidence of the pain, and ten days later the calcification had disappeared.

Calcification of an intervertebral disk is rare in children. In 1945, Weens found only 5 examples in the literature, to which he added one (*J. Pediat.* 26: 178, 1945. *Abst. in Radiology* 46: 97, 1946). Clinical signs are localized pain and deformity. The calcified deposits are reversible and are situated in the nucleus pulposus. They are of acute traumatic etiology and may be a manifestation of a calcified hematoma. In the older age groups, on the other hand, calcification generally appears without clinical signs and for the most part is irreversible. It is generally found lower in the spine and localized to the annulus fibrosus. It is probably of degenerative origin.

Six roentgenograms; 1 table.

LAWRENCE A. DAVIS, M.D.  
University of Louisville

**Erosion of Bone Produced by Glomus Tumour.** W. Robert Harris. *Canad. M. A. J.* 70: 684-685, June 1954.

A case is reported of a subungual glomus of the left middle finger which had produced erosion of the underlying bone. The patient had been incapacitated for three years by agonizing pain in the finger. The slightest pressure on the nail caused intense pain, and the blanching produced by the pressure disclosed a small spot of persistent purple color. Roentgen examination revealed excavation of the underlying bone at a point corresponding to the purple spot, with a lining of cortical bone. Excision of the tumor brought about complete relief of symptoms.

Three roentgenograms.

### THE SPINAL CORD

**Intraspinal Tumor, a Difficult Diagnosis.** William R. Chambers. *Am. J. Surg.* 87: 824-829, June 1954.

The author presents 6 cases of intraspinal tumor, all of which were diagnosed as some other type of nervous system disease, the correct diagnosis being delayed because of failure of a complete neurological examination in conjunction with x-ray studies, including myelography. The diagnoses included multiple sclerosis, spinal syphilis, "kidney trouble," anterior poliomyelitis, and peripheral neuritis. In each case x-ray examination indicated the true diagnosis. In all there was unquestionable increase in the serum protein of the spinal fluid.

Roentgenographic indications of intraspinal tumor included erosion of the spine, widening of the interpeduncular spaces, and unquestionable blocks in the spinal canal, demonstrable on the myelogram.

The similarity of the manifestations of intraspinal tumors to other diseases would be discouraging if it were not that in each case there is a clue to the diagnosis which, if duly noted and properly evaluated, will lead the examiner to eventual success. Missing the diagnosis of intraspinal tumor is a medical tragedy, for the majority of such tumors in adults are benign and removable in their early stages, and the patient often completely recovers.

Two roentgenograms.

WINSTON C. HOLMAN, M.D.  
Shreveport, La.

## GYNECOLOGY AND OBSTETRICS

**The Application of Pelvic Venography to Diagnostic Problems Associated with Cancer of the Female Genital Tract.** Salim J. Dalali, Albert A. Plentl, and Arnold L. Bachman. *Surg., Gynec. & Obst.* **98:** 735-742, June 1954.

The authors describe a simple method for x-ray visualization of the pelvic veins and its application to a variety of clinical problems encountered in the treatment of gynecologic cancer. Venography is done through simultaneous injection of both femoral veins, percutaneously if possible, with pressure applied over the inferior vena cava. The only complication has been local extravasation of the contrast medium.

Some 40 venograms were obtained in patients with cancer of the female genital tract. The studies were undertaken to (1) differentiate between lymphatic and venous occlusion as a cause of edema; (2) to determine the point of union of the internal and external iliac veins for localizing pelvic lymph nodes prior to radiotherapy; (3) to demonstrate the collateral circulation of the pelvis; (4) to correlate *in vivo* venographic findings with those at autopsy. Seven cases are reported, and illustrations are included demonstrating normal circulation and obstruction of femoral and external iliac veins with collateral circulation *via* pubic, circumflex, obturator, epigastric, and iliolumbar veins, as well as instances of narrowing by extrinsic pressure and of partial obstruction by thrombophlebitis.

The authors make a number of observations. Without abdominal compression the external and common iliac veins and the inferior vena cava can be outlined. With abdominal compression there is a retrograde flow into the internal iliac vein, uterine vein, vesical plexus, and left ovarian vein. Partial obstruction due to local external pressure produces a smooth narrowing of the veins; thrombophlebitis causes an irregular mottled appearance.

Occlusion of the external iliac vein alone does not necessarily cause edema. In one case observed, the obturator vein alone provided an adequate collateral channel. If obstruction of the major vessels is associated with thrombophlebitis, cellulitis or adenitis, then, in spite of adequate collateral venous channels, peripheral edema may occur. This edema must be attributed to inflammatory changes or lymphatic obstruction, or both.

The internal iliac veins appear to be the preferred collateral channel when the common iliac vein is blocked. The iliolumbar veins are utilized only if the internal iliac veins are inadequate or obstructed.

Ten roentgenograms. STANLEY ABO, M.D.  
Mount Sinai Hospital, Cleveland

**On the Localization of Tubal Obstruction in Cases of Sterility from Different Causes.** Wolfgang Magnusson. *Acta radiol.* **41:** 513-516, June 1954.

It has been shown that in tubal endometriosis and tubal tuberculosis typical roentgen-anatomic signs often make diagnosis possible. In obstruction due to other inflammatory conditions in the tubes or pelvic peritoneum, no specific sign has been related to the origin or nature of the process.

Believing that the site of an obstruction might furnish some information as to its cause, the author investigated 189 cases of sterility in which endometriosis and tuberculosis could be excluded. Complications of

the puerperium and of abortion were the most frequent causes of bilateral blocking of the tubes at the uterine ends. Gonorrhea was seldom followed by obstruction at this site. Peritonitis associated with appendicitis more frequently produced obstruction in the fimbriated ends.

CLAUDE D. BAKER, M.D.  
University of Louisville

**Isometric Pelvimetry.** John W. Walsh, Stuart L. Haas, and Marian E. Maclean. *Am. J. Obst. & Gynec.* **68:** 674-690, August 1954.

Seven hundred consecutive unselected cases are analyzed in which isometric pelvimetry was done according to the method developed by Steele, McLane, and Javert (see Steele and Javert: *Am. J. Obst. & Gynec.* **43:** 600, 1942, and McLane: *Am. J. Obst. & Gynec.* **50:** 495, 1945. Abst. in *Radiology* **40:** 108, 1943, and **47:** 313, 1946). The authors feel that the two-film (anteroposterior and lateral) technic has the following advantages: the mother and fetus are subjected to minimum inconvenience and exposure to x-rays, the films are easily marked and interpreted, and it is possible to measure all the major diameters of the pelvis.

The procedure itself and system of interpretation are outlined in detail. Apparently the method is no more accurate than others, nor does it need to be. The measurement of all the major pelvic diameters is important, since no single diameter is of significance unless integrated with related diameters. Compensatory space existing in other areas is of great importance, as has been pointed out by various workers. Cephalopelvic relationship is of the utmost concern.

The authors feel that the obstetrician should be responsible for mensuration and interpretation of the films. [This is a point which has been discussed before by radiologists and obstetricians alike. To make a universal rule is perhaps unjustifiable. At times the consulting radiologist may have a more thorough knowledge of existing conditions than the obstetrician, and the reverse is, of course, equally true.]

Fifteen figures, including 2 roentgenograms; 4 tables.  
R. L. EGAN, M.D.  
Jefferson Hospital, Philadelphia

**Analysis of Consecutive Radiological Pelvimetries on European Primiparae at the Queen Victoria Hospital, Johannesburg.** K. V. O. Gunn. *South African M. J.* **28:** 500-502, June 12, 1954.

This paper is based upon approximately 2,000 pelvimetric examinations of European primiparae carried out at the Queen Victoria Hospital, Johannesburg. The radiographic technic employed is not described. The average inlet area for the group was 123 sq. cm., and the average outlet area 103 sq. cm. The most frequent inlet area was between 111 and 130 sq. cm. (53.5 per cent) and the most frequent outlet area between 91 and 110 sq. cm. (50.3 per cent). There were inlets larger than 111 sq. cm. in 80 per cent of the group and outlets larger than 91 sq. cm. in 83.8 per cent.

According to the criteria established for this series, the pelvis of 115 women (5.8 per cent) were below average in size as regards both inlet and outlet; 76 of these patients had normal deliveries, and 43 of the infants were of average or above-average weight. In the remaining 39 cases forceps assistance (23) or cesarean section (16) was required. In 9 cases in

which cesarean section was done, the infant was below-average weight; that is, only 1 patient in 200 required cesarean section because of general contraction of the pelvis. The average birthweight for males was 7 lb. 5 oz., for females 7 lb.

Five tables.

### THE GENITOURINARY SYSTEM

**Aortography as an Aid in the Management of Renal Lesions.** Edgar Burns and Robert G. Hendon. *Ann. Surg.* 139: 617-623, May 1954.

The authors assess the diagnostic value of translumbar aortography from an experience of more than 300 examinations. Among the most important kidney conditions producing changes in the renal circulation in which aortography may be of aid are inflammatory diseases, congenital abnormalities, neoplasms of the renal cortex, and obstructive lesions of the pedicle. Carcinomas are detected by their tendency to cause pooling of the contrast medium and are differentiated from cysts by the avascularity of the latter.

Aortography can now be accomplished in most cases without complications of importance.

It is contraindicated in persons allergic to iodides, those with impaired renal or hepatic function, and those with aneurysms of the abdominal aorta. It is also difficult to perform in patients with severe aortic sclerosis. The procedure is not completely without danger, as renal damage and even death have been reported following its performance.

Nine roentgenograms. HARRY HAUSER, M.D.  
Cleveland City Hospital

**Renal Complications from Aortography.** Gerald M. Miller, Edwin J. Wylie, and Frank Hinman, Jr. *Surgery* 35: 885-896, June 1954.

During the past two years aortography has been performed on approximately 250 patients at the University of California School of Medicine (San Francisco). In 7 of these damage to the kidney was observed. In 3 cases the renal damage was unilateral and resulted from direct trauma at the time of the aortographic examination. Not only was the needle misdirected in each instance, but the complicating factors of excessive injection pressure, large volumes of contrast medium, and possible irritation by the medium were also present. Pressure and volume are interrelated factors, the contrast medium causing damage by being forced out of the capillaries or by direct irritation because of high concentration. Renal atrophy developed in 1 patient. In the second a high proportion of the contrast medium was apparently injected directly into an aberrant artery going from the aorta to the lower pole of the kidney; the patient seems to have suffered no untoward effects. In the third, temporary non-function with severe hypertension occurred, with spontaneous return to normal within three months.

In the remaining 4 patients damage was indirect and bilateral. In 3, the two-needle technic was used and over 60 c.c. of contrast medium was injected. In the fourth, 50 c.c. of medium was introduced under high pressure, and there appeared to be immediate parenchymal damage. All 4 patients recovered completely, after periods of oliguria of ten or eleven days. Two of the 4 showed evidence of idiosyncrasy to Diodrast.

Animal experiments showed that high injection pressures may cause interstitial extravasation of the

medium, leading to late renal fibrosis. To insure against such damage following aortography, certain limitations in technic appear desirable. If the whole aortic tree must be filled (as before vascular surgery), then at least 50 c.c. of contrast medium is needed. To prevent excessive pressure (or the danger of trauma by too large a needle), it has been found advisable to use two smaller 17- or 18-gauge needles and inject by hand with two syringes. To avoid direct injection of the renal vessels (or other aortic branches), the needle tips should be angulated sharply upward so that they enter the aorta just below the diaphragm and 2 to 3 cm. above the renal vessels. Long needles are required.

For urologic purposes, 25 c.c. of contrast medium has been found to be adequate. Even this quantity of medium injected directly into the renal artery could be damaging, and the authors advocate, especially for the occasional operator, the making of a scout film after injection of 5 c.c. to determine the position of the tip of the needle. If it lies within the lumen of the renal artery or mesenteric vessels, or if there is extravasation, it may then be moved. This precaution might have obviated the complications in at least 3 of the authors' cases.

Fifteen roentgenograms; 2 photographs; 2 photomicrographs; 1 chart.

**Pyelography After Direct Puncture of the Renal Pelvis.** Ingmar Wickbom. *Acta radiol.* 41: 505-512, June 1954.

When poor renal function prevents the completion of excretory pyelography and the aortogram does not give the necessary information, the author uses direct injection of the contrast medium into the renal pelvis to outline the collecting system. His procedure can also be used where there is complete obstruction of the ureter. Apparently he prefers direct puncture to retrograde pyelography.

With the patient prone, two metallic rods with small metal balls at 1.0-cm. intervals are placed at right angles over the skin of the back with the crossing point approximating the renal pelvis. A similar rod is placed across the flank, and postero-anterior and left lateral films are obtained. From the co-ordinate system thus visualized, the site of puncture and the depth of the renal pelvis are estimated, and the injection of the opaque material is made accordingly. Excellent visualization was obtained in the 5 cases in which the procedure was employed. No untoward symptoms were noted, either during the injection or later. Short summaries of the 5 cases with appropriate roentgenograms are included.

Twelve roentgenograms.

LAWRENCE A. DAVIS, M.D.  
University of Louisville

**A New Theory on the Formation of Renal Calculi.** Reginald J. Carr. *Brit. J. Urol.* 26: 105-117, June 1954.

The author reviews the theories of the formation and growth of urinary calculi and presents the details of his own study, which includes the technic of micro-radiography and diffraction x-ray analysis. His theory is based on the view that the lymphatic system forms a drainage mechanism whereby normal microliths and concretions are removed from the kidney in a manner exactly comparable to the removal of foreign particles from the alveoli into the mediastinal lymph

nodes. He believes that a breakdown of this mechanism results in the formation of renal calculi as a result of (1) overloading of the mechanism by an excessive number of microliths, such as occurs in hyperparathyroidism, other disorders of calcium excretion, and possibly absence or deficiency of protective colloids, etc., or (2) impairment of the mechanism of lymphatic drainage due to previous inflammatory changes with subsequent fibrosis.

Twenty illustrations, including 11 roentgenograms and microradiographs.

**Rapid Identification of Urinary Calculi Through Use of X-Ray Analysis.** W. J. Smothers and L. H. Siegel. *J. Urol.* 71: 647-649, May 1954.

The identification of materials forming a urinary calculus is of value because, depending upon its composition, either certain dietary changes can be made, or drugs prescribed, which will reduce the probability of further calculus formation. Almost all calculi are crystalline and therefore possess definite physical properties.

Recent improvements in x-ray equipment have eliminated the need for films in the determination of the nature of urinary calculi. A Geiger tube which scans the diffraction arc is used to register the positions and intensities of the diffracted beams. Identification of the components is possible through correlation of the x-ray pattern with those recorded in a file prepared by the American Society of Testing Materials. The time required to analyze calculi through the use of film is approximately two to three hours, while satisfactory results with the Geiger tube arrangement can be obtained in approximately fifteen to forty-five minutes.

Powder patterns were obtained for several human urinary calculi. Results showed 2 calculi consisting of oxalate, 3 of mixed oxalate and phosphate, 1 of phosphate, and 1 of cystine. These findings compare favorably with those of Pries and Frondel, who used chemical and microscopic methods to study 700 urinary calculi.

To the authors' knowledge, the identification of  $\text{Ca}(\text{H}_2\text{PO}_4)_2 \cdot 2\text{H}_2\text{O}$  in urinary calculi has not been previously reported.

Two illustrations.

HARRY HAUSER, M.D.  
Cleveland City Hospital

**Ureteral Occlusion by Barium Granuloma.** James S. Elliot and Milton L. Rosenberg. *J. Urol.* 71: 692-694, June 1954.

A case is reported in which retroperitoneal extravasation of barium took place in the course of a barium enema study prior to treatment of a rectal polyp. Six weeks later oliguria occurred, progressing within a week to complete anuria. Nausea and vomiting then developed, and the patient became comatose. Blood chemistry studies revealed the blood urea nitrogen to be 131 mg. per cent and creatinine 15.6 mg. per cent. Upon catheterization, the bladder was found to be empty. Catheters were passed up each ureter after meeting resistance between 2 and 5 cm. Within a twenty-four-hour period, the patient excreted 4,500 c.c. of urine through indwelling catheters, and within forty-eight hours the blood chemistry had returned to normal.

Exploration showed the retrovesical and peri-ureteral areas to be involved in a dense fibrotic mass of inflammatory tissue. Tiny streaks of barium were observed in the lymphatics. No definite pools or locules of

barium could be discovered but the material appeared to be spread diffusely through the pelvis, and the ureters were incorporated in a dense, inelastic mass. Since no definite surgical treatment was possible, simple closure was done. Convalescence was uneventful. At weekly intervals, the ureters were dilated, and six weeks after the onset of anuria the urinary output was excellent. Follow-up films and studies made six and ten months after the initial accident showed no change in distribution or amount of barium.

Two roentgenograms. ALFRED O. MILLER, M.D.  
Louisville, Ky.

**The Renal Circulation after Temporary Occlusion of the Renal Artery.** P. M. Daniel, Marjorie M. L. Prichard, and J. N. Ward-McQuaid. *Brit. J. Urol.* 26: 118-126, June 1954.

The experiments reported in the present paper were carried out to determine the state of the renal circulation after a period of total renal ischemia sufficiently long to cause characteristic pathological changes in the kidney.

The renal vessels of rabbits were completely occluded for two hours. Angiograms made twenty-four and forty-eight hours after release of the clamp showed some abnormality at the site of occlusion. In most instances the intrarenal vessels were constricted and the circulation through the kidney, particularly through the peripheral cortex, was severely impaired. This picture was unaltered after administration of hexamethonium bromide.

In animals which survived, angiograms obtained at six and eight days after the period of temporary occlusion, showed that the renal vasoconstriction had relaxed and the circulation through the kidney had greatly improved.

In the kidneys of those rabbits which did not survive for more than seventy-two hours after release of the clamp, histologic changes similar to those seen in human cases of "crush syndrome" were observed. The lesions were largely confined to the secreting tubules and were of variable severity and patchy in distribution. They were most extensive in the cortex but were also present in the outer zone of the medulla. The kidneys of rabbits surviving for six or more days were essentially normal.

Nine roentgenograms; 2 photomicrographs.

#### MISCELLANEOUS

**Reversible Metastatic Calcification (Milk Drinker's Syndrome).** Murray Dworetzky. *J.A.M.A.* 155: 830-832, June 26, 1954.

A 50-year-old man, a writer, gave a history of typical symptoms of duodenal ulcer of twenty-eight years duration, usually recurring every spring and fall. Because of frequent sour eructations associated with periods of tension, he had for ten years been taking, daily, twelve to twenty Sippy powders (each containing 0.65 gm. calcium carbonate and 2.0 gm. sodium bicarbonate), and for three years had been drinking six to eight quarts of milk a day. Pain and stiffness of the shoulders had been present for two and a half years. Because of this, the Sippy powders were discontinued but the patient was allowed to drink three or four quarts of milk a day.

Roentgenograms showed normal mineralization of the osseous structures, together with massive soft-

tissue calcification about the right shoulder and small calcific deposits in the soft tissues adjacent to the greater tuberosity of the left humerus, along the volar aspect of the right wrist, and adjacent to the proximal interphalangeal joints of the toes. There was extensive calcification of the abdominal aorta and iliac vessels, and a small calculus in the right kidney pelvis. The milk intake was limited to less than pint daily, and an aluminum gel preparation was prescribed.

Nearly two years later, the patient returned because of painless gross hematuria. He was hospitalized and a small stone was removed from the right kidney, which was found on analysis to contain calcium phosphate, calcium carbonate, and ammonium phosphate. A Sulkowitch test on the urine showed calcium 1+. Serum calcium and phosphorus and alkaline phosphatase determinations were normal. Blood urea nitrogen values were elevated to 57 mg. per 100 c.c., and the serum carbon dioxide content ranged from 23 to 20 mEq. per liter. Urea clearance was considerably reduced. The striking finding was the roentgenographic demonstration of clearing of most of the soft-tissue calcifications from the sites involved twenty-six months previously; the exceptions were those in the abdominal aorta and iliac arteries.

The patient reported that the pain and stiffness in the joints had begun to lessen progressively within a month or two of his reduction in milk intake and ingestion of Gelusil tablets. For several months he had had no recurrence of these symptoms. Similarly, there had been no return of intermittent claudication that previously had occurred with fast walking.

The author considers the calcinosis in this patient to have been a metastatic process secondary to a prolonged intake of large quantities of milk and alkali.

Four roentgenograms. ARTHUR S. TUCKER, M.D.  
Cleveland Clinic

#### TECHNIC—DOSIMETRIC ASPECTS.

**The X-ray Picture.** G. Spiegler. *Fortschr. a. d. Geb. d. Röntgenstrahlen* 80: 754-762, June 1954. (In German)

Extensive measurements have shown that the attenuation of roentgen rays passing through the abdomen of a patient is equivalent to that obtained with filtration of approximately 0.5 mm. copper, while the human chest is roughly equivalent to 0.35 mm. copper. In order to produce a satisfactory blackening on the x-ray film in a cassette with intensifying screens, about 1 to 4 milliroentgens must be applied to the film. If no intensifying screens are used, the requirement is about 20 to 80 milliroentgens. While in deep x-ray therapy the surface dose is measured and the dose to the lesion is calculated mathematically by means of tables, in diagnostic studies a certain depth dose is forced upon the film irrespective of the amount that must be applied to the skin. The half-value layer of

the usual diagnostic x-ray beam after passage through the abdomen is about 0.2 to 0.25 mm. copper. Only 0.5 per cent of the radiation applied to the surface of the abdomen reaches the film after penetrating the body. For chest films the radiation reaching the film amounts to 5 to 7 per cent of the skin dose.

If a film is exposed to a beam of a given constant dose, for instance 10 milliroentgens, it will show a certain degree of blackening, dependent to a certain extent upon the kilovoltage. If no intensifying screens are used, this dependence amounts to only about 10 per cent in the 60-120-kv range. With intensifying screens, the variation of the blackening with changes in kilovoltage becomes quite pronounced, particularly if the screens have a calcium tungsten base.

Much planning and large amounts of money have been devoted to the production of the best possible diagnostic x-ray apparatus; yet it is almost impossible, or at least extremely difficult, to reproduce exactly a given type of x-ray film after a lapse of time, and the eye of the radiologist has to make constant adjustments in comparative studies. The author feels that much could be accomplished by spending more engineering effort on the production of viewing boxes. The human eye cannot see fine gradations of density between an extreme contrast of light and darkness. Neither the flat high-kilovoltage film lacking contrast nor, on the other hand, the very contrasty "exhibition film" is ideal for viewing by the radiologist. A way should be found to increase fine gradations of contrast, as between the kidney and the surrounding soft tissues, and at the same time suppress too much contrast, as between the heavy bones and the soft tissues.

Two graphs. WILLIAM A. MARSHALL, M.D.  
Chicago, Ill.

**Note on Horizontal Tomography.** R. Lamy. *J. franç. de méd. et chir. thorac.* 8: 225-243, 1954. (In French)

To the classic methods of frontal and sagittal tomography there has now been added a method of taking horizontal tomograms. At first this method was limited largely to the thorax, but its use has been extended to the study of abdominal viscera, thanks to the utilization of diverse contrast gases.

Cardiovascular pulsations and imperfect apnea in the dyspneic patient contribute to lack of definition. In addition, unless rotation of the patient and film traverses a substantial angle (near 180°), there will be geometric distortion so that a sphere may appear ovoid.

With careful technic, useful information is obtained in studying the anatomicopathologic features of pleural and pulmonary parenchymal lesions. On the other hand, bronchial changes are not so precisely demonstrated as with the sagittal type of tomography.

Twenty-one roentgenograms; 10 drawings.

CHARLES M. NICE, JR., M.D.  
University of Minnesota

#### RADIOTHERAPY

**Pathological Study of Retinoblastoma Treated by Radon Seeds and Radium Disks.** H. B. Stallard. *Arch. Ophth.* 51: 573-588, May 1954.

In a paper delivered before the Section of Ophthalmology of the New York Academy of Medicine, the author discusses the pathological findings in retino-

blastoma treated by radon seeds and radium disks. The statistics, observations, and comments concerning radiotherapy are based on 3 groups of patients: the author's own series of 36 patients (37 eyes), 16 treated by radon seeds (1934-48) and 21 by radium disks (1948-52); 5 patients treated by radon seeds by Foster

Moore between 1929 and 1937; and 25 patients treated by other surgeons in the United States, Great Britain, Canada, and Australia. Eight eyes containing irradiated retinoblastoma were studied.

In the author's opinion, when one-third or less of the retina is involved in a retinoblastoma there is reasonable hope that the tumor may be eradicated by radiotherapy. With few exceptions, the results are bad when one-half or more of the retina is already destroyed. In such cases retinal detachment is generally present or, if not, will almost certainly occur after irradiation. Later sequelae are severe intraocular hemorrhage, iridocyclitis, complicated glaucoma, and endophthalmitis. Irradiation often fails when the choroid is infiltrated. In such advanced cases it would seem advisable to excise the eye with 10 mm. of the optic nerve and to give postoperative irradiation to the orbit.

The dose is still empirical: 2,500 to 3,500 r at the summit of the neoplasm is generally effective. In some patients the neoplasm is more radiosensitive than in others.

The author believes that "it is desirable to bring the therapeutic artillery as close as possible to the target and to hit hard and quickly, with a concentration of fire that is known to be both effective and reasonably safe for the eye." To achieve this, radium disks made to fit the scleral curvature evenly are better than radon seeds and the other applicators so far used. This technic is preferable to long-range shooting by heavy doses from radium needles fixed in Columbia paste plaques or from the radium "bomb," for both these methods are disastrous for the eye and are often quite ineffective in destroying the neoplasm.

Although deep x-ray therapy is successful in many cases in which less than one-third of the retina is affected by the neoplasm, it has the technical disadvantages of protracted treatment and the difficulty of maintaining the necessary immobility of a child's head. It also produces a higher incidence of serious complications than the application of either a radium disk or a radon seed.

Eleven illustrations.

**Cancer of the Breast. The Results of Radical Mastectomy and Radiotherapy in Two Hospitals.** L. H. Garland, H. A. Hill, M. E. Mottram, and M. A. Sisson. *Surg., Gynec. & Obst.* 98: 700-704, June 1954.

The results of treatment of cancer of the breast in a 1,200-bed county clinic for indigent patients are compared with those in a 250-bed private hospital. The five-year survival rates of 100 patients consecutively admitted to each hospital between 1946 and 1948 are compared. The age distribution of the two series was similar, but the county institution had 51 cases of disease in Stages III and IV compared to 3 in the private hospital.

In the county hospital, treatment consisted in radical mastectomy in 39 cases (16 with postoperative irradiation); simple mastectomy in 9 cases (7 with postoperative radiotherapy); radiotherapy alone in 20 cases. In 32 cases there was no treatment to the primary site. At the private hospital, radical mastectomy was done in 91 cases (with postoperative radiotherapy in 9); simple mastectomy in 5 cases (2 with postoperative radiotherapy); radiotherapy alone in 2 cases; biopsy alone in 1 case. One case received no treatment to the primary lesion.

The relative five-year survival rates for Stage I disease (Portmann) were 70 per cent at the county institution and 65 per cent at the private hospital; for Stage II disease, 40 and 42 per cent respectively. Considering all patients who received some form of treatment to the primary lesion, the relative survival rates were 37 per cent at the county institution and 50 per cent at the private hospital. The difference in these figures is believed to be due to the much greater number of cases with advanced disease in the county institution.

The authors state that the results in Stage II are slightly inferior to those reported by McWhirter, who used simple mastectomy plus vigorous postoperative radiotherapy. This paper deals only with patients admitted to a hospital for treatment, and is largely based on radical mastectomy; McWhirter's figures included all those seen with the disease, whether accepted for treatment or not. The authors feel that the fact that the "relative" results in this series are not considerably better than McWhirter's "absolute" results tends to speak in favor of his method.

Four tables.

J. H. GROVE, M.D.

Mount Sinai Hospital, Cleveland

**Role of Irradiation Therapy in the Treatment of Neuroblastoma.** James M. Keegan, Harry W. Burnett, Jr., and Florence N. Marshall. *Pediatrics* 13: 521-526, June 1954.

A case is reported to illustrate the early effects of radiation on neuroblastoma and to re-emphasize the radiosensitivity and possible radiocurability of this malignant neoplasm, even after incomplete removal and/or localized metastasis. Nineteen cases with long-term survival following irradiation are recorded in the literature.

The authors' patient was a white female infant of two and a half months with diffuse liver metastases, proved by biopsy, and a paraspinal mass. She was treated through two opposing right upper quadrant portals, 10 cm. in diameter, receiving a calculated tumor dose of 2,810 r in thirty-six days (factors: 230 kv, 50-cm. target-skin distance, 1.0 mm. Cu plus 1.0 mm. Al filtration, 2.0 mm. Cu h.v.l.). The dose to the anterior portal was 1,950 r in air; to the posterior portal, 1,750 r in air. Re-exploration two months after treatment was begun revealed a normal-sized but scirrhouss liver, biopsy of which showed multiple areas of dense collagenous fibrous tissue but no residual tumor. Biopsy of nodules in and about the right sympathetic chain showed a few remaining altered tumor cells. A second twenty-one-day course of therapy was directed more medially, with the same factors except for 2 mm. Cu plus 1 mm. Al filter and 2.6 mm. Cu h.v.l., for a calculated tumor dose of 1,785 r. There was no evidence of recurrence in more than two years follow-up.

Three roentgenograms; 3 photomicrographs; 2 photographs; 1 table. H. G. PETERSON, JR., M.D.

New Britain, Conn.

**Urological Complications Following Radiological and Surgical Treatment of Carcinoma of Cervix.** R. Gordon Douglas and Stanley J. Birnbaum. *South. M. J.* 47: 559-566, June 1954.

Since July 1, 1948, it has been the policy at the New York Lying-In Hospital to treat cancer of the uterine cervix with primary irradiation followed by radical

surgery where feasible. About 100 patients have been so treated. Sixty-four of these cases have been analyzed in detail for urinary and other postoperative complications. Patients with Stage 0 lesions were not subjected to extensive surgery and accordingly were excluded from the study. In 7 of the 64 cases the cancer occurred in a "cervical stump" remaining after previous subtotal hysterectomy. The cases are divided according to the League of Nations classification, as follows: Stage I, 22; Stage II, 36; Stage III, 5; Stage IV, 1. All but 3 of the cancers were squamous-cell.

On entry into the hospital, every patient admitted with a diagnosis of cervical cancer undergoes a thorough investigation including examination under anesthesia, intravenous pyelography, cystoscopy, barium enema studies, proctoscopy, and chest and skeletal x-ray examination. She then receives a complete course of x-ray therapy, including 2,000 to 2,500 r (in air) to each of six anterior and posterior pelvic ports, and up to 6,000 or 7,000 r through a vaginal cone. This treatment extends over a period of about six weeks. The patient is then discharged for six weeks. At the end of this time she is re-admitted, her condition is re-evaluated, and all of the previously mentioned studies are repeated. Preoperative preparation is then begun for those considered candidates for surgery. Intravenous pyelography and other urinary tract procedures are repeated routinely during the postoperative period and on occasion thereafter.

Fifty-five of the patients in the present series received preliminary x-ray therapy approximating the technic described; this was followed by radical hysterectomy (or excision of the cervical stump) in 49 cases and by even more extensive surgery in the remaining 6 (3 pelvic extirpations and 3 subtotal cystectomies). All of this latter group had primary surgery on the urinary tract in addition to the gynecological procedures. Nine patients in Stage I received no preliminary irradiation; all underwent radical hysterectomy and node dissection only.

All patients had a transient bladder atony that persisted from two to eight weeks and occasionally longer. In all patients gross hematuria occurred, usually lasting from two to five days. Eight patients continued to have chronic bladder dysfunction, with alteration in capacity, incontinence, or deformity of the bladder. Urinary tract infection was recorded in 54 patients; it was probably masked by intensive anti-microbial therapy in the remaining cases. Chronic urinary tract infection or repeated exacerbations of infection occurred in 13 patients. Some degree of diminished kidney function, as demonstrated by a transient elevation of the non-protein nitrogen or a delay in function on intravenous pyelography, was found in 31 cases; there was usually a return to preoperative levels in five to seven days, but in 8 cases diminution of function or no function persisted, with a "silent" kidney developing in several instances. One of the most striking findings was a postoperative hydropic change in the upper urinary tract, observed in 35 patients. This was usually mild in nature and bilateral, perhaps due to traumatic peri-ureteral edema or to severance of the ureteral nerve supply. In 19 cases, however, these changes persisted long after operation. Urinary tract

fistulas occurred in 6 patients. Eight patients required secondary urological operations.

The most common non-urological complications were persistent distal edema, phlebitis, and rectovaginal fistulas.

A comparative study was made of patients treated with and those without preliminary irradiation. The irradiated patients appeared to have more numerous and more severe complications. The authors believe, however, that the improvement in prognosis with combined therapy more than compensates for the urological damage incurred.

Five charts; 4 tables.

**Hodgkin's Disease.** Frederick W. O'Brien and Frederick W. O'Brien, Jr. Am. J. Roentgenol. 71: 1007-1016, June 1954.

It is extremely difficult to abstract this particular paper, since it is in the nature of a summary of the clinical, pathologic, etiologic, and therapeutic aspects of Hodgkin's disease. The bibliography represents a comprehensive survey of the literature covering a period of many years and is a very worth-while part of the article.

The authors reproduce 13 roentgen films of various lesions of the lymphoma group, including one extremely interesting osteolytic lesion in the proximal shaft of the fibula which responded well to external irradiation.

Various forms of treatment, including surgery and irradiation, and the use of such chemotherapeutic agents as nitrogen mustard and triethylene melamine, are considered. The authors believe that mustard and triethylene melamine may be useful adjuvants in the treatment of generalized Hodgkin's disease and in so-called radiation-fast cases. "We are not so reactionary," they state, "as to believe that chemotherapy may not have opened up an important approach to the treatment of the lymphoma group. We deprecate, however, their use routinely by internists and hematologists in early or late disease, without regard to the natural history of the disease and the known benefit of irradiation. A close collaboration between internist, surgeon, and radiation therapist is essential. Until further evidence is presented, we feel that irradiation remains the cornerstone of therapeutics in Hodgkin's disease."

A series of 128 cases treated by the authors by irradiation is reported. Of 31 patients with disease initially localized to one or more groups of peripheral nodes, 11 remained alive without clinical disease beyond five years (1 ten and 1 twelve years). Of 97 patients with generalized disease on admission, 9 survived for five years, but only 1 of these was without demonstrable disease. Six of the series received nitrogen mustard.

In the Discussion following the paper, Dr. William Harris of New York suggested that some patients with compression syndromes, such as a superior vena cava syndrome or compression of the spinal cord, may be better treated with nitrogen mustard than with external radiation. [This idea will certainly provoke controversy, since most radiation therapists feel that external radiation is far superior to nitrogen mustard for a localized lesion.]

O. M. RICHARDSON, M.D.  
University of Louisville

## RADIOISOTOPES

**Developments in Internal Dose Determinations.** K. Z. Morgan and M. R. Ford. Nucleonics 12: 32-39, June 1954.

This article contains a detailed exposition of the considerations and assumptions involved in arriving at values of maximum permissible concentrations of radioisotopes for chronic exposures. It further develops a basis for calculation of maximum permissible concentrations for single exposures. The results of such calculations are presented in a detailed table for each radioactive isotope, for both ingestion and inhalation. The use of the table is clearly outlined in examples in the text. Calculations are also presented on the amount of excretion following both single and chronic exposures.

Four graphs; 1 table. JOHN S. LAUGHLIN, PH.D.  
Memorial Center, New York

**Standardized Co<sup>60</sup> Source Capsule for Teletherapy.** Marshall Bruer. Nucleonics 12: 58-59, June 1954.

This article gives the details of a standardized source capsule for telecobalt units, as agreed upon by the representatives of equipment manufacturers and representatives of the U. S. Atomic Energy Commission and the Atomic Energy Commission of Canada, Ltd. A figure illustrates the various components of the source holders. The size is said to be compatible with all source sizes in use or projected in Canada or the United States. For a specific activity of 50 curies/gram the holder will accommodate over 4,000 curies of cobalt 60. The design incorporates two lead wire seals to avoid any leakage of cobalt particles.

One illustration. JOHN S. LAUGHLIN, PH.D.  
Memorial Center, New York

**The Treatment of Carcinoma of the Prostate by Interstitial Radiation with Radioactive Gold (Au<sup>198</sup>): A Follow-up Report.** R. H. Flocks, H. D. Kerr, H. B. Elkins, and D. A. Culp. J. Urol. 71: 628-633, May 1954.

The authors present a follow-up report of 130 patients with carcinoma of the prostate treated by radioactive gold (see J. Urol. 68: 510, 1952. Abst. in Radiology 61: 154, 1953). The most satisfactory dosage has been 2 mc per gram of tissue, with an upper limit of 150 mc. The following amounts have been injected: in glands of 30 to 50 gm., 15 to 20 c.c.; in glands of 50 or more gm., 20 to 30 c.c.

Follow-up of three to eighteen months in 100 cases shows the following points of interest: (1) Negative biopsies have been obtained in a significant number of patients. Clinical arrest has been obtained in 48 cases. (2) With improvement in technic, the incidence of complications, particularly rectal difficulties, have been tremendously decreased. In the first 50 cases, 24 complications occurred. In the second 50 cases, only 4 minor complications were encountered. (3) Secondary injections through a perineally placed needle are of value for the destruction of nodules which were not completely destroyed at the first sitting.

Further studies are being carried out on the utilization of beta radiation for the destruction of carcinoma of the prostate, alone and in combination with other types of therapy.

Six illustrations.

HARRY HAUSER, M.D.  
Cleveland City Hospital

**Intraprostatic Injection of Radioactive Colloids. I. Distribution and Excretion Following Injection in the Dog.** John A. D. Cooper, George J. Bulkley, and Vincent J. O'Conor. J. Urol. 71: 624-627, May 1945.

Interest in treatment of carcinoma of the prostate by radiation has been revived by the favorable results reported by Flocks and his co-workers following the intraprostatic injection of colloidal radiogold (see preceding abstract). Since studies on the distribution and excretion of the radiocolloid following injection into the prostate have not been reported, the present authors undertook the experiments reported here. Comparisons were made of radioactive colloidal chromic phosphate and colloidal radiogold with regard to their excretion and distribution after intraprostate injection in dogs.

The majority of particles of chromic phosphate were reported to be between 1 and 2 microns in diameter; the suspension was stabilized in 2 per cent pectin. The colloidal gold particles were 0.002 to 0.007 microns in diameter and the suspension was stabilized with 5 per cent gelatin. The preparations were diluted behind lead shields to an activity of 1 to 3 millicuries per milliliter. The suspensions contained 200 T.U. of hyaluronidase and 0.01 ml. of 1:1,000 epinephrine per milliliter. The doses ranged from 2 to 4 milliliters containing 3 to 9 mc. of the isotope.

Mongrel dogs varying in weight from 9 to 20 kilos were used. Attempts were made to select old animals in order to obtain large prostate glands. The suspension of radioactive colloid was injected with a lead-shielded syringe similar to that described by Flocks and his associates, and a 2 inch 21-gauge hypodermic needle. One half of the total dose to be administered was infiltrated into each half of the gland. The animals were placed in metabolic cages for collection of urine for radioactive assay. Blood samples were obtained at intervals for estimating the amount of radioactive colloid present in the circulation. Two weeks later, in the case of chromic phosphate, and one week later in the case of radiogold injection, the dogs were sacrificed and samples of tissue were obtained for studies on the distribution of the colloid in the body.

The urinary excretion of radioactive colloids showed wide variation. Three animals which were injected with the same preparation of colloid on the same day excreted from 44 to 63 per cent of the administered dose in the first week. The other animals, which were injected in groups of two with different preparations, gave much lower excretions. The results may be due to a difference in particle size or to a difference in injection technic not apparent at the time of injection.

Plasma concentrations of the colloids were fairly constant over the seven-day period. The range of levels for animals receiving chromic phosphate ( $1.8 \times 10^{-2}$  per cent of the dose administered per liter of plasma) was somewhat lower than that following gold ( $1.1 \text{ to } 10.0 \times 10^{-3}$  per cent per liter).

Data on the distribution of the colloids within the various organs of the animals are presented in table form.

The data obtained for urinary excretion in the dog cannot be used to predict excretion in patients receiving injections of the colloid for carcinoma of the prostate. The difference in size, consistency, and structure of the

neoplastic human gland could result in entirely different excretion patterns. Preliminary data on urinary excretion of patients who have received intraprostatic injections of radiogold indicate that much smaller amounts appear in the urine than are found for the dog.

The much greater concentration of radioactivity found in the regional lymph nodes after the injection of gold as compared to chromic phosphate is noteworthy. This difference is of importance, since it would be desirable to obtain tumoricidal doses of radiation in the lymph nodes draining the prostatic area. The distribution of chromic phosphate and gold in various organs agrees with that reported for similar size particles administered intravenously. The amount present in the liver was slightly higher in animals receiving radiogold, while the spleen contained more activity following injection of colloidal chromic phosphate. A negligible amount was found in the lung, kidney, and bladder.

Two graphs; 1 table.

HARRY HAUSER, M.D.  
Cleveland City Hospital

**Radioactive Gold in Prostatic Cancer.** Robert O. Beadles and James M. Lewis. *Rocky Mountain M. J.* 51: 528-530, June 1954.

Ten patients at the Colorado Springs Medical Center were given radioactive gold for localized (as far as could be determined) prostatic cancer. In the authors' opinion, the results are encouraging. The first patient was seen in February 1952 after he had had six months of estrogenic therapy with no significant improvement. He had a large, nodular, fixed, hard prostate with overflow incontinence. Part of the gland was removed surgically and 30 millicuries of radioactive gold were injected into the remaining cancerous tissue. At the time of the report, twenty-one months later, the patient was free of any evidence of cancer.

In 7 of the 10 cases, obstructing tissue required surgical removal. Three patients were treated only with gold. Eight patients had had previous attempts at estrogenic control, either with oral therapy, orchectomy, or both.

In 5 patients there was no clinical evidence of demonstrable cancer at the time of the report. One patient showed signs of inadequate treatment. Two patients had been treated too recently for evaluation. There were 2 deaths in the series.

**Transport of Radioactive Colloidal Gold Between Serous Cavities.** Irving I. Cowan, Roland S. Cron, Gordon F. Burgess, and Frank G. Karioris. *Surg., Gynec. & Obst.* 98: 721-724, June 1954.

The authors have taken the opportunity to study the transport of particulate matter between serous cavities afforded by a patient with liposarcoma of the mesentery, under treatment with Au<sup>198</sup> for ascites and bilateral pleural effusion.

The study was designed to answer three questions: (1) Would colloidal Au<sup>198</sup> instilled intraperitoneally be transported to the pleural cavity? (2) Would colloidal Au<sup>198</sup> instilled intrapleurally be transported to the peritoneal cavity? (3) Would intra-abdominally administered Au<sup>198</sup> have an effect on the formation of pleural fluid?

After intraperitoneal instillation of 150 mc of Au<sup>198</sup>, specimens of fluid were withdrawn from the right

pleural space; a total thoracentesis was done at forty-six and a half hours. All of the specimens contained radioactive material. A high concentration was present at two hours, and 3.4 per cent of the intraperitoneal dose after forty-six and a half hours.

Eight weeks later 56.8 mc of Au<sup>198</sup> was placed in the right pleural space. Samples of ascitic fluid were removed through an indwelling polyethylene tube at various intervals of thirty minutes to twenty-eight hours and the peritoneum was then allowed to drain overnight. About 5.5 per cent of the radioactive material instilled in the chest was recovered from the peritoneum. The concentration was maximum at one hour. From then on it decreased exponentially with time. This rate of decrease has been shown to be typical of Au<sup>198</sup> injected directly into the peritoneal cavity, wherein the gold is removed from the free fluid by phagocytosis and deposited on the serous walls. In this case, the concentration of the Au<sup>198</sup> was ten times as great in the cell mass as in the supernatant fluid after centrifugation. Some form of rapid trans-diaphragmatic lymphatic transport appears to be the most feasible explanation of the transference of the colloidal radioactive gold between serous cavities.

There was little therapeutic effect obtained from the Au<sup>198</sup> in the authors' patient.

Two photomicrographs; 2 graphs.

ALVIN GREENBERG, M.D.  
Mount Sinai Hospital, Cleveland

**Studies on Blood-Brain Barrier with Radioactive Phosphorus. IV. Spatial Aspects of Phosphate Exchange Between Plasma and Brain.** Louis Bakay. *Arch. Neurol. & Psychiat.* 71: 673-683, June 1954.

**Studies on Blood-Brain Barrier with Radioactive Phosphorus. V. Effect of Cerebral Injuries and Infarction on the Barrier.** Louis Bakay. *Arch. Neurol. & Psychiat.* 73: 2-12, January 1955.

In the fourth of a series of studies on the blood-brain barrier with radioactive phosphorus (see Absts. in *Radiology* 59: 632, 1952; 61: 468, 1953; 62: 795, 1954), experiments are described whereby it was hoped to obtain additional data on the rate and location of phosphate exchange between plasma and the brain.

Cats were used as the experimental animals, and the concentration of P<sup>32</sup> and the specific activity of plasma and various parts of the brain were determined over a period of thirty minutes to three weeks after a single injection of the isotope. From these studies it appeared that, so far as phosphates are concerned, diffusion equilibrium is never reached between the plasma and the cerebrospinal fluid. Diffusion of the phosphate into the surface areas of the cerebrum, both internal and external, was relatively rapid, an equilibrium being reached with the cerebrospinal fluid in one or two days and with the plasma on the fifth day after administration of the tracer. In the deep white matter, diffusion was much slower, three or four days and seven or eight days being required before equilibrium was reached with the cerebrospinal fluid and plasma, respectively. The increased activity of the surface areas is attributed to the transport of phosphate via the cerebrospinal fluid. Diffusion of P<sup>32</sup> from the ventricular fluid was delayed in animals in which the ventricle was obliterated with paraffin prior to the injection of the isotope.

It is concluded that plasma phosphatase enters the central nervous system by transcapillary exchange and by an indirect route using the cerebrospinal fluid

as an intermediary. The following theory is advanced: During the initial phase of absorption,  $P^{32}$  enters the brain via the cerebrospinal fluid after it has passed the blood-cerebrospinal fluid barrier. This phase is characterized by a large concentration of the tracer in the surface areas and a decline in activity of the cerebrospinal fluid. The pattern of diffusion is the same whether the tracer has been injected intravenously or intracisternally. The later phase of absorption shows slow and gradual increase of  $P^{32}$  concentration in the entire brain, presumably due to a direct passage of the tracer through the blood-brain barrier by transcapillary exchange. The process marking the initial phase remains superimposed on this later phase but loses its importance as time elapses. Hence, the difference in  $P^{32}$  content between the surface areas and the depth becomes less pronounced, although it is still slightly perceptible three weeks after the injection.

The fifth paper of the series describes further experiments on cats, in which the effect of cerebral injuries and infarction on the blood-brain barrier were studied. The  $P^{32}$  was injected intravenously in one group of animals and they were killed two hours later, at various intervals after the injury. A second group received intraperitoneal injections ten minutes after injury and were sacrificed at intervals ranging from forty-seven minutes to nine days later. In still another group space-taking lesions were produced by the injections of paraffin just prior to injection of  $P^{32}$ .

Considerably higher amounts of the tracer were found in the injured area and in the surrounding edematous zone than in the normal brain. This local increase in the permeability of the blood-brain barrier was the greatest during the first hours after the operation, but it was still present six weeks afterwards. Time curves of  $P^{32}$  concentration in the lesion were compared with those for the normal brain. It was found that, by destroying the blood-brain barrier for  $P^{32}$  by trauma, the cerebral lesion is converted into a "non-protected" area, which does not differ in this respect from other tissues of the organism.

A similar high concentration of  $P^{32}$  was observed in a cerebral infarct in a patient who died shortly after receiving an injection of  $P^{32}$ .

The results of these studies are compared with similar investigations in which vital dyes were used for indicators. The isotope findings are discussed with special regard to the application of  $P^{32}$  in the localization of brain tumors.

**Use of Radioactive Phosphorus in Detection of Intraocular Neoplasms.** I. J. Eisenberg, I. H. Leopold, and D. Sklaroff. *Arch. Ophth.* 51: 633-641, May 1954.

Following unsatisfactory results with the use of diiodofluorescein in the detection of intraocular neoplasms, the authors turned to radiophosphorus, which they believe to be a more suitable isotope for this purpose. Using  $P^{32}$ , they sought to answer the following questions: (1) What variations in concentration are found in the normal eye? (2) What should be considered a positive [pathological] concentration as compared with the normal eye? (3) What effect would intraocular lesions other than neoplasms have on the concentration of  $P^{32}$ ?

The technic employed in the investigation was as follows: A dose of 500 mc of radiophosphorus was injected intravenously, and, after an interval of sixty minutes, a count was taken over the skin of the lobe

of an ear, being recorded as the number of discharges per minute (this figure to be used only as a background). A count was also taken over each quadrant of the normal eye. With an ophthalmoscope, the intraocular lesion was visualized, and if possible the counter was placed directly over the area of involvement. Several counts were taken, and an average count per minute was determined.

The variations in concentration of  $P^{32}$  in the normal eye were found to run as high as 28 per cent from the arithmetic mean, though generally the variation was less than 20 per cent. A variation of 30 per cent or more should be considered significant.

With serous detachments and choroidal and vitreous hemorrhages without signs of inflammation, there was no significant concentration of  $P^{32}$ . In neoplasms in the posterior segment of the globe, a significant concentration of  $P^{32}$  may or may not occur, depending on the size, activity, and location of the tumor. Neoplasms in the anterior segment of the globe showed a significant detectable concentration of the isotope.

Six figures; 2 tables.

**The Gamma-Ray Dose in Carcinoma of the Thyroid Treated by Radio-Iodine.** A. F. Phillips. *Acta Endocrinol.* 41: 533-544, June 1954.

This paper is concerned with the irregular distribution of radioactive iodine in a carcinoma of the thyroid, with two specific cases used as illustrations. It is well known fact that the main therapeutic radiation from radioiodine ( $I^{131}$ ) is due to beta ray ionization. However, the beta ray of this isotope has a very short range through tissue; the dose is greatly reduced at a distance of 1 mm. from the source and is negligible for therapeutic purposes at a distance of 2 mm. The gamma rays from  $I^{131}$  produce very little ionization but have a much greater penetrative power. Any point in a tumor receives an appreciable contribution of gamma radiation from all the radioactivity within some 30 cm. radius.

The author has shown that in a spherical mass with uniform distribution of activity the dose is at a maximum in the center and falls off gradually toward the periphery of the lesion. Only in very large tumors, therefore, which take up considerable amounts of radioiodine, would the gamma ray content be sufficient to produce a useful addition to the beta ray doses if the radioactivity were uniformly distributed. In order to obtain therapeutically useful gamma ray dosage to the more distant regions of the tumor, it becomes necessary to administer tremendous amounts of  $I^{131}$ , which in many cases is not feasible because of the severe radiational damage to other organs.

A method of measurement of the radioactivity—especially of gamma rays—in carcinoma of the thyroid is described. For this purpose, sections of the tumor, which has been made radioactive by administration of  $I^{131}$ , usually forty-eight hours prior to surgery, are placed on photographic film and autoradiographs are made. For details of measurement the original paper must be consulted.

The author has shown that certain segments of the tumors in his two cases received very little radioiodine and, as a result, practically no beta ionization. The only therapeutic effects to the areas came as a result of the gamma ray dosage, which was of slight degree.

In general, it may be stated that it is almost impossible to give large enough gamma ray doses by means

of  $I^{131}$  to produce a cure. The author mentions the fact that  $I^{134}$  emits beta rays with three times the energy of  $I^{131}$ , which would penetrate approximately four times as far in tissues, and also emits more energy as gamma rays per disintegration. It is suggested that further work be done with other isotopes of iodine in the treatment of carcinoma of the thyroid.

Four radioautographs; 7 photomicrographs; 1 photograph; 1 graph. O. M. RICHARDSON, M.D. University of Louisville

**Suitability of Tumor-Bearing Mice for Predicting Relative Usefulness of Isotopes in Brain Tumors. Comparative Clinical and Laboratory Study in Localization and Treatment of Brain Tumors with  $P^{32}$ ,  $Na^{21}$ ,  $K^{42}$ , and Sodium Borate.** Herbert B. Locksley, William H. Sweet, Henry J. Powsner, and Elias Dow. Arch. Neurol. & Psychiat. 71: 684-698, June 1954.

Since the number of brain tumors seen in any one clinic is relatively small, it would be an almost endless process to test the various radioactive isotopes available to determine which are most effective in these lesions. The authors present a study of comparative uptake of various isotopes in key tissues of mice previously implanted subcutaneously with a transferable glioblastoma or astrocytoma. They conclude that this method is quite feasible for preliminary screening of an isotope for possible selective uptake by brain tumors. Natu-

rally the results are not immediately applicable to human patients but they do provide a means of eliminating useless clinical trials.

Comparative studies in mice and patients with  $P^{32}$ ,  $K^{42}$ , and sodium borate (borax) demonstrated a remarkably close agreement in the concentration ratios observed between tumor and brain. Measurements of the extracellular sodium space for the various organs in mice also showed close agreement with values for rats, dogs, rabbits, and monkeys. Studies on the potassium contents of mouse organs indicate that these fall within the range for other commonly employed experimental animals. This favorable comparison of data in mice and patients is further substantiated in a study of a series of positron-emitting isotopes, including  $Mn^{43}$ ,  $Rb^{84}$ , and  $As^{74}$ . When a selection is to be made among a group of particularly favorable isotopes, however, it is desirable to obtain enough human data to define a "factor of correlation" which embodies differences in excretion, general metabolic rate, and the characteristics of the particular mouse tumor being used. The most rapid and valid method for obtaining these correlation data in patients is an extension of the Geiger probe technic of tumor localization, whereby continuous uptake curves may be obtained over a period of hours or days in individual patients.

One roentgenogram; 20 graphs; 6 tables. ZAC F. ENDRESS, M.D. Pontiac, Mich.

## RADIATION EFFECTS

**Tricho-X-Ray Cancer. Another Case of Radiation-Induced Tumorigenesis.** Norman Lenson. New England J. Med. 250: 952-954, June 3, 1954.

Radiation damage is capable of affecting all cells. This paper considers only its effect on the skin. Acute or chronic radiodermatitis is the most frequent effect, with radiation-induced cancer a familiar sequel. This is usually the squamous-cell type.

A squamous-cell carcinoma resulting from "Tricho" treatment for superfluous hair about the chin some thirty years previously is reported. The Tricho system consists of repeated treatments by a machine allegedly issuing short vibratory waves (0.3 of an Angström) intended to dry up the dermal papillae.

The author's report constitutes further evidence that Tricho treatment is neither safe nor scientific, but extremely hazardous and capable of producing malignant degeneration. He reminds us that the best method of treatment of radiation cancer is its prevention.

Two photographs; 1 photomicrograph.

C. M. GREENWALD, M.D.  
Cleveland Clinic

**Leukemia in Atomic Bomb Survivors. I. General Observations.** Robert D. Lange, William C. Moloney, and Tokuso Yamawaki. Blood 9: 574-585, June 1954.

Seventy-five cases of leukemia were studied in individuals exposed to atomic bombings. There was a much higher incidence of leukemia in the groups closer to the radiation center; 65 cases were found among 76,891 survivors who had been within 2,500 meters of the radiation center. There were only 10 cases among 159,285 people beyond 2,500 meters. The incidence of acute radiation symptoms had also

been much higher in the groups closer to the radiation center.

Chronic myelogenous leukemia was the most frequent type; acute myelogenous leukemia was second in frequency; there was only one case of chronic lymphatic leukemia, but this is a comparatively rare disease among Japanese.

In the largest number of cases the onset of leukemia was five years after the bombing. There has been a steady decrease in incidence since that time.

Six graphs; 4 tables. RICHARD E. BUENGER, M.D. Chicago, Ill.

**Alterations in the Glial Cells Following Irradiation of the Brain in Primates.** Arthur Arnold and Percival Bailey. Arch. Path. 57: 383-391, May 1954.

**Effects of Betatron Radiations on the Brain of Primates.** Arthur Arnold, Percival Bailey, and John S. Laughlin. Neurology 4: 165-178, March 1954.

In the first of the two papers listed above the authors report their observations, made over some five years, of the effects of conventional roentgen irradiation and very high-energy roentgen rays on the normal nervous system of the monkey and man. The conventional radiation was in the 200-400 kv range; the high-energy rays were produced by the betatron. The experimental procedure in monkeys has been previously described (Radiology 62: 37, 1954). The general plan of the human investigations was to study the glial cells in normal cerebral tissues which had been irradiated in the course of therapy but were not in the immediate vicinity of a tumor.

It was found that the normal adult glial cell of the primate brain can be adversely affected by irradiations. The alterations in the function as well as the

structure of these cells can be correlated with (a) the total dose of radiation, (b) the intensity of dose administration, (c) uniformity of dose distribution within the tissue, and (d) the duration of time of observation after irradiation.

The appearance of hypertrophied glial cells following irradiation of normal tissue is significant for the pathologist, inasmuch as similar cellular forms appear in tumor tissue.

The second paper is concerned primarily with the clinical and pathological effects of the 23-mev rays produced by the betatron on the brains of monkeys. The dose range was from 375 to 14,000 r. The conclusions reached bear out those of an earlier paper (cited above), namely, that the central nervous system is much more radiosensitive than has been generally conceded; that the changes observed are direct effects of the radiation and not secondary to vascular changes; that the white matter of the deep portions of the centrum semiovale, internal capsules, and brain stem are peculiarly responsive to x-irradiation.

The capacity of radiations to produce a delayed necrosis, which may be fatal if it occurs in the brain stem, must be taken into consideration in planning radiation therapy of brain tumors.

The first paper includes 7 photomicrographs; the second 5 illustrations and 1 table.

**Use of Chlorpromazine in Radiation Sickness and Nausea from Other Causes.** Joseph H. Marks. New England J. Med. 250: 999-1001, June 10, 1954.

Chlorpromazine is believed to be antagonistic to the action of apomorphine, a centrally acting emetic. The author reports its use (in the form of Thorazine) in radiation sickness, but his criteria for establishing that diagnosis are not clearly stated. Included in his series were patients with severe vomiting "which had been present before the x-ray treatments were started in most cases."

The results obtained in 84 cases over the course of nine months are recorded. Only 4 patients were not benefited by chlorpromazine. The drug is also said to be useful to control the nausea incident to nitrogen mustard therapy.

Patients are first given a 10 mg. dose of chlorpromazine before each meal. If nausea is not relieved, this dose is raised to 25 mg. For severe, intractable vomiting, intramuscular injections of 50 mg. once or twice daily usually controlled the symptoms.

[It is quite possible that chlorpromazine is a valuable drug for the relief of radiation sickness, but this uncritical report should not be used in evidence either way.—M. R. C.]

Two tables.

MORTIMER R. CAMIEL, M.D.  
Brooklyn, N. Y.

## RADIOBIOLOGY

**Mechanism of Radiation Anencephaly, Anophthalmia, and Pituitary Anomalies. Repair in the Mammalian Embryo.** Samuel P. Hicks, with the assistance of Regina C. O'Brien and Elizabeth C. Newcomb. Arch Path. 57: 363-377, May 1954.

Experiments were carried out to demonstrate the reparative process in the rat embryo and to show its extremely important role in the modification of patterns of malformation resulting from irradiation at precisely known times. The authors discuss the relationship of their findings to those in previous investigations.

Low doses of x-rays (150 to 205 r) administered to pregnant rats and mice cause in the embryos and fetuses a fairly reproducible series of malformations that have been approximately correlated with the time of injury. Embryos removed from animals irradiated on the ninth day after evidence of insemination showed severe head and, especially, brain malformations (anencephaly); irradiation on the tenth day resulted in anophthalmia; on the eleventh and twelfth days in hydrocephalus and other brain deformities; and on the eleventh to thirteenth days in cord and spinal anomalies. Various patterns of microcephaly and later cerebellar deformities followed irradiation from the twelfth day till the neonatal period. Other visual, skeletal and limb deformities occurred in the nine-to-twelve-day period.

The procedure of irradiating the pregnant animal on a certain estimated day of gestation, with removal of some embryos four hours later (ample time for radiation necrosis of vulnerable cells to become visible), and the remaining fetuses at one or more subsequent times, provides a close approximation of the average age of the litter of embryos, the sites of radiation injury, and the resultant malformation. The present experiments demonstrate that, despite extensive necrosis of

differentiating neural cells and cells in an analogous stage in other developing systems, complete or nearly complete repair can occur in many zones. Radiation malformations are therefore the result of a balance between radiation damage and the capacity for repair in any given anlage or developing zone. In the presomite to first somites stage (ninth day), differentiating cells in the neural plate and mesenchyme are destroyed by irradiation, and anencephaly and anophthalmia result. Paradoxically, on the tenth day, three to eight somites, malformation is essentially limited to the eyes; yet radionecrosis in the embryo is very severe in the neural folds, neural tube and groove, somites, and condensing areas of mesenchyme. Virtually only the optic pits (and their adjacent mesenchyme and ectoderm?) fail to recover. Repair is from the primitive mitotic cells, such as neurectoderm and some primitive mesenchyme cells, which are fairly radioresistant.

Some of the possible underlying reasons for the malformation patterns and future lines of investigation are also discussed.

Four figures.

**Regionally Fractionated X-Irradiation Equivalent in Dose to Total-Body Exposure.** M. N. Swift, S. T. Takeita, and V. P. Bond. Radiation Res. 1: 241-252, June 1954.

In the experiments described by the authors whole-body x-irradiation of mice and rats was accomplished by regionally fractionated exposure, i.e., by exposing first one portion of the body, and then, after a short interval, the entire remaining portion. The lethal effects of given doses (as measured in air) of whole-body irradiation administered in this manner and by the conventional single exposure method were compared. It seemed reasonable to expect a possible diminution of

lethal effect through regional fractionation of the radiation dose on the supposition that recovery factors emanating from the body region shielded during the first irradiation would act to promote recovery in the part exposed in that irradiation. The time intervals allowed between the two irradiations were considered sufficient for such action to take place. The experiments fall into two general categories, based upon the manner in which the body was subdivided for irradiation. These were: abdomen *vs.* remainder of the body and (2) spleen *vs.* entire body exclusive of spleen.

Considerably lower mortality resulted from 875 r irradiation of the entire body in mice if the abdomen was exposed ninety minutes prior to, or following, exposure of the remainder of the body. Results were similar regardless of the order in which the exposures were carried out, and the degree of protection so obtained was similar to that afforded by shielding the exteriorized spleen during total-body irradiation.

Radiation mortality in rats following 650 and 750 r was also decreased, but to a lesser extent, by the use of this divided exposure technic. The degree of protection obtained in rats appeared similar, irrespective of the order in which the two portions of the body were irradiated, or of the time interval (ten or one hundred and twenty minutes) between exposures.

Shielding the exteriorized spleens of mice during total-body exposure to 900 or 1,000 r brought about an appreciable reduction in radiation mortality even though the spleens alone had been irradiated with these same doses prior to exposure of the body. The data suggest that a somewhat greater reduction may be obtained by allowing a four-hour interval between irradiation of spleen and body than a ten-minute interval.

These findings may be interpreted in each instance in terms of the existence of a factor (or factors) emanating from the body region shielded during the first irradiation, and acting to protect or promote recovery in the region or organ exposed in that irradiation.

The irradiation procedure employed in these experiments, that of giving the equivalent of total-body irradiation by means of regionally fractionated exposures, provides a method whereby the effect of shielding various body regions or organs on radiation recovery phenomena of this kind can be studied apart from certain complications inherent in partial body irradiation procedures.

One graph; 3 tables.

#### Hematologic Findings in the Total Body X-Irradiated Hamster. George P. Fulton, David L. Jofte, Roma Kagan, and Brenton R. Lutz. *Blood* 9: 622-631, June 1954.

Hematologic determinations on hamsters x-irradiated with 600, 1000, 1200, and 1500 r revealed the following changes:

1. Decrease in red blood corpuscles and hemoglobin about nine days after irradiation or just before death in the lethal group.
2. Decrease in white-cell count with reversal of neutrophil-lymphocyte ratio within twenty-four hours.
3. Decrease in platelet count and increase in clotting time just prior to death in the lethal group.

Transillumination of everted cheek pouches failed to show white cell or platelet adhesiveness to vascular endothelium as a cause of the leukopenia or thrombocytopenia, as has been previously postulated. Extrav-

asation did not account for the erythrocytopenia. Lack of replacement of blood cells by the damaged hematopoietic system probably accounts for the pancytopenia.

One photomicrograph; 4 tables.

RICHARD E. BUENGER, M.D.  
Chicago, Ill.

#### Changes in Some Gastrointestinal Functions Following X-Irradiation. Paul F. Fenton and Harrison M. Dickson. *Am. J. Physiol.* 177: 528-530, June 1954.

A study of the effect of total-body irradiation on gastric motility and other digestive processes is described. Mice were used in the experiments. A dose of 500 r was administered with a 200-kv x-ray machine operating at 20 ma and a distance of 20 cm.; filtration 0.5 mm. Cu and 1.0 mm. Al; rate 240 r/min. The LD 50/30 days was about 550 r.

A glucose-Congo red solution was given orally to irradiated and control animals, and the rate of gastric emptying and the recovery of the gastric emptying process were investigated. A marker ( $\text{Cr}_2\text{O}_7$ ) was incorporated at a 1 per cent level into a high-fat diet, and the food intake, the quantity of feces excreted, and the  $\text{Cr}_2\text{O}_7$  and nitrogen content of the feces were determined daily both before and after irradiation.

Gastric emptying and food intake in mice were found to be reduced for a period of less than twenty-four hours after irradiation with a dose of 500 r. The inhibitory effect of hypertonic solutions on gastric evacuation was abolished by irradiation. Fecal output of total solids and of nitrogen was reduced for forty-eight hours after irradiation. The concentration of  $\text{Cr}_2\text{O}_7$  marker in the feces was reduced for a two-day period. Irradiation had no effect on the pancreatic and intestinal amylase content under the conditions employed in these experiments. The amylase content of the pancreas was found to decrease with age.

Two charts; 2 tables.

#### Studies on Susceptibility to Infection Following Ionizing Radiation. I. The Time of Onset and Duration of the Endogenous Bacteremias in Mice. Carolyn W. Hammond, Marianne Tompkins, and C. Phillip Miller. *J. Exper. Med.* 99: 405-410, May 1, 1954.

Bacteremia of enteric origin has been found to occur in a high percentage of mice during the second week following a single exposure to a moderate dose of ionizing radiation (*J. Lab. & Clin. Med.* 38: 331, 1951. Abst. in *Radiology* 59: 159, 1952). In the investigation described here an attempt was made to determine the time of onset and duration of the bacteremias.

Daily cultures of blood from the tail were made on mice from the seventh to the seventeenth or twenty-second day after exposure to 550 r total-body x-irradiation. Seven mice with negative blood cultures survived to the twenty-seventh day, at which time the animals were sacrificed and found to have negative heart's blood cultures. Every mouse with bacteremia died. Heart's blood cultures postmortem always confirmed the bacteriological findings in the serial cultures. Most of the bacteremias occurred between the seventh and fifteenth days.

The duration of the bacteremia varied with the microorganism which caused it. *Pseudomonas* bacteremia was always rapidly fatal. Those caused by *Proteus* and *E. coli* continued for a maximum of seventy-two

and forty-eight hours. Of longest duration was bacteremia caused by *Paracolobactrum* which was tolerated for as long as five days.

One chart; 1 table.

**Studies on Susceptibility to Infection Following Ionizing Radiation. II. Its Estimation by Oral Inoculation at Different Times Post Irradiation.** Carolyn W. Hammond, Margaret Colling, Dorothy B. Cooper, and C. Phillip Miller. *J. Exper. Med.* 99: 411-418, May 1, 1954.

The investigation described in the previous abstract comprised observations on the duration of bacteremias which occurred in mice during the second week after exposure to 550 r total-body x-irradiation. The most rapidly fatal were those caused by *Pseudomonas aeruginosa*. Every mouse in which this organism was found died within twenty-four hours of its discovery in the blood stream.

In the present experiment, mice were inoculated by mouth at different times (two hours, five days, and eleven days) after a single exposure to 550 r total-body x-irradiation. The inocula contained approximately 10<sup>7</sup> *Pseudomonas aeruginosa* which was found to be quite harmless for unirradiated mice.

Comparison of the cumulative mortality curves and of the incidence of *Pseudomonas* bacteremia showed the susceptibility of mice to infection by this route to be greatest on the eleventh day, somewhat less on the fifth day post-irradiation, and least of all directly after irradiation. Since damage to the intestinal mucosa has been found to be maximal within the first few hours after exposure to doses of x-irradiation in the range employed, it seems reasonable to conclude that the increased susceptibility is not due to increased permeability of the mucosa of the gut, but to impairment of the animal's natural defenses against infection.

Two illustrations.

**The Morphogenesis of Pituitary Tumors Induced by Radiothyroidectomy in the Mouse and the Effects of Their Transplantation on the Pituitary Body of the Host.** N. S. Halmi and W. D. Gude. *Am. J. Path.* 30: 403-419, May-June 1954.

The authors investigated the changes in the pituitary body of the mouse at various intervals after destruction of the thyroid gland and the alterations which can be seen in the hypophyses of both radiothyroidectomized and normal mice bearing transplanted pituitary tumors.

The following groups of mice were studied: (a) 15 normal males and females; (b) 90 radiothyroidectomized animals killed at intervals ranging from ten to over six hundred days after thyroid destruction; (c) 21 radiothyroidectomized hosts bearing dependent or autonomous transplanted tumors\*; (d) 6 normal hosts bearing autonomous grafted growths; (e) 10 male mice killed at intervals of thirty, sixty, and one hundred days after castration. All radiothyroidectomized animals received over 200  $\mu$ c of I<sup>131</sup>, a dose sufficient to destroy the thyroid gland completely or at least to abolish the responsiveness of the few possibly surviving thyroid cells to thyrotrophin.

The pituitary body of the mouse possesses three types of chromophil cells: acidophils, beta cells, and delta cells. The latter two classes together are the "basophils" of the older nomenclature. Radiothyroidectomy leads to a rapid transformation of the beta cells into "thyroidectomy cells," through degranulation,

hyperplasia, and hypertrophy. After six months, multifocal adenomas made up of typical or dedifferentiated thyroidectomy cells appear. Ten months after thyroid destruction gross tumors composed of similar but usually even less differentiated cells arise in the pituitary body. A transient hypertrophy of the delta cells occurs prior to the appearance of the adenomas. There is little change in the acidophils until they are "crowded out" by the tumor.

Radiothyroidectomized hosts bearing grafted dependent or autonomous pituitary tumors may show a partial reappearance of beta granules in the thyroidectomy cells and a regression of the delta cells. In 2 of 7 female hosts, pituitary growths exhibiting histologic signs suggestive of malignant change were encountered.

Autonomous tumors grafted into normal hosts cause depression of all three types of chromophil cells, especially the acidophils.

The significance of these findings in the histophysiology of the pituitary body of the mouse is discussed.

Twenty photomicrographs.

\*"Dependent" tumors are those requiring for their growth destruction of the host's thyroid gland. "Autonomous" tumors are those which grow in normal hosts.

**Influences of the Mode of Irradiation, of Hypophysectomy, of Gonadotropic Hormones, and of Chemical Radioprotective Substances on the Response of the Rabbit Ovary to X-Rays.** Paul Desaive. *Acta radiol.* 41: 545-557, June 1954. (In French)

The author's experiments on adult rabbits had two objectives: (1) determination of the threshold dose for sterilization and destruction of the follicular system of the adult rabbit ovary; (2) study of several factors that modify follicular radiosensitivity, such as destruction of the hypophysis and preliminary administration of gonadotropins (Prolan Bayer) or a radioprotective agent (beta-mercapto-ethylamine).

A single dose of 2,500 r (measured on the skin) at 165 kv, 4 ma, with 5 mm. Al filter, sterilized the ovary and in most cases destroyed the follicular apparatus completely. When the radiation was fractionated into five equal consecutive doses, the threshold for sterilization was lowered to 2,000 r and for complete destruction to 2,250 r. A similar lowering of the threshold dose was obtained following administration of gonadotropin and destruction of the pituitary gland by either radiologic or mechanical means. Intravenous administration of a protective agent, such as beta-mercapto-ethylamine, immediately before irradiation raised the threshold doses considerably, to 2,750 r for sterilization and more than 3,000 r for complete destruction. It is thought that this chemical radioprotective agent acts, at least in part, on a cellular level.

A future publication will deal with the variation in follicular radiosensitivity related to biologic factors.

[Ellinger's contribution on Endocrine Influences on Radiosensitivity (*Radiol. clin.* 23: 182, 1954. Abst. in *Radiology* 64: 478, 1955) is of interest in this connection.—C. V. S.]

Two charts.

CHRISTIAN V. CIMMINO, M.D.  
Fredericksburg, Va.

**Modification of the Radiation Syndrome in the Chick by Partial Body Shielding.** S. Phyllis Sterner, Emily J. Christian, and Austin M. Brues. *Radiation Res.* 1: 270-281, June 1954.

The relative importance of direct radiation injury

and of indirect effects to subsequent mortality was studied in the chick by shielding parts of the body during x-ray exposure. The bird kidney is especially radiosensitive, and its relation to the initial radiation response was examined by determinations of blood urate concentration and urate excretion rate.

Three- to four-day-old male chicks were used in the investigation. A lead sheet,  $\frac{1}{4}$  inch thick, was placed over the part of the body to be shielded. The structures covered by the lead plate were originally determined by roentgenograms, and diagrams were made of chick and shield positions in order to standardize the shielded area in each exposure group. The irradiated birds were divided into two groups, depending upon whether a small or a large part of the body was shielded during exposure. All birds were exposed to 1,000 r x-rays, at a rate of 35 r/min, 0.98 mm. Cu half-value layer, 18 inch distance.

It was found that shielding small areas of the body during irradiation reduced subsequent mortality. Shielding the kidney region prevented severe renal lesions, but normal function was not maintained. Conversely, irradiation of only the kidney region produced renal lesions and a substantial mortality, especially in the initial post-irradiation period. Results indicate that early renal failure is the result of both

direct radiation injury and indirect systemic effects. Renal failure is, however, only one of multiple possible mechanisms that contribute to early radiation mortality in the bird following exposure at a rate above 10 r/min. Seven figures; 4 tables.

**Increased Tolerance to Hypoxia in Irradiated and in Food-Deprived Rats.** B. D. Newsom and D. J. Kimeldorf. *Am. J. Physiol.* 177: 390-394, June 1954.

The authors found an increase in tolerance to lethal levels of hypoxia over that of controls following x-irradiation in rats. The effect disappears approximately five days after exposure to 500 and 600 r and corresponds in duration to the post-irradiation period of anorexia. When deprived of food for seventy-two hours, non-irradiated animals have an increased tolerance to hypoxia comparable to that of irradiated animals. Seventy-two hours after irradiation there is an increase in the time required for asphyxiation. This increase can be duplicated in non-irradiated animals by food deprivation and is not dependent on carbon dioxide accumulation. These experiments demonstrate that the increased tolerance to hypoxia which follows irradiation is, at least in part, a consequence of post-irradiation anorexia.

Five tables.



